This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

12^{00}

pp. X, II, 160. Fold. plte, plat.

1817
ARTES VERITAS SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

St. 27/A

QC
517
.R28

A
SUMMARY VIEW
OF THE
SPONTANEOUS ELECTRICITY
OF THE
EARTH AND ATMOSPHERE.

Price Three Shillings and Sixpence.

A
SUMMARY VIEW
OF THE
SPONTANEOUS ELECTRICITY
OF THE
EARTH AND ATMOSPHERE;
WHEREIN THE CAUSES OF
LIGHTNING AND THUNDER,
AS WELL AS THE
CONSTANT ELECTRIFICATION
OF THE
CLOUDS AND VAPOURS, SUSPENDED IN THE AIR,
ARE EXPLAINED.
WITH SOME NEW EXPERIMENTS AND OBSERVATIONS,
TENDING TO ILLUSTRATE
THE SUBJECT OF ATMOSPHERICAL ELECTRICITY;
TO WHICH IS SUBJOINED THE
ATMOSPHERICO-ELECTRICAL JOURNAL,
KEPT DURING TWO YEARS,
AS PRESENTED TO AND PUBLISHED BY
THE ROYAL SOCIETY OF LONDON.

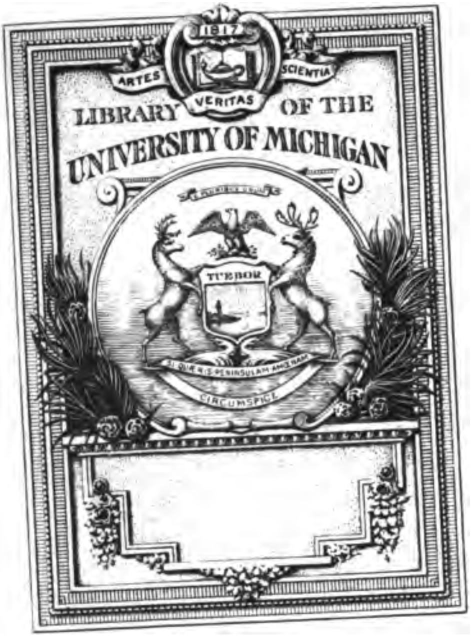
BY JOHN READ,
OF KNIGHTSBRIDGE, LONDON.

LONDON:
PRINTED FOR THE AUTHOR, OF WHOM IT MAY BE HAD;
SOLD BY ELMSLEY, STRAND; RICHARDSON, ROYAL EXCHANGE;
HOOKHAM & CARPENTER, BOND-STREET; DEIGHTON, HOLBORN.

1793.

12^{00}

Mo. x, ii, 160. Fold. plte. plat./



St. 27/1

QC
517
.R28

A
SUMMARY VIEW
OF THE
SPONTANEOUS ELECTRICITY
OF THE
EARTH AND ATMOSPHERE.

Price Three Shillings and Sixpence.

A
SUMMARY VIEW
OF THE
SPONTANEOUS ELECTRICITY
OF THE
EARTH AND ATMOSPHERE;
WHEREIN THE CAUSES OF
LIGHTNING AND THUNDER,
AS WELL AS THE
CONSTANT ELECTRIFICATION
OF THE
CLOUDS AND VAPOURS, SUSPENDED IN THE AIR,
ARE EXPLAINED.
WITH SOME NEW EXPERIMENTS AND OBSERVATIONS,
TENDING TO ILLUSTRATE
THE SUBJECT OF ATMOSPHERICAL ELECTRICITY;
TO WHICH IS SUBJOINED THE
ATMOSPHERICO-ELECTRICAL JOURNAL,
KEPT DURING TWO YEARS,
AS PRESENTED TO AND PUBLISHED BY
THE ROYAL SOCIETY OF LONDON.

BY JOHN READ,
OF KNIGHTSBRIDGE, LONDON.

LONDON:
PRINTED FOR THE AUTHOR, OF WHOM IT MAY BE HAD;
SOLD BY ELMSLEY, STRAND; RICHARDSON, ROYAL EXCHANGE;
HOOKHAM & CARPENTER, BOND-STREET; DEIGHTON, HOLBORN.

1793.

NU

Hist. of Science
Hutchi
6-20-44
$1.30

06-22-41

TO

Sir JOSEPH BANKS, Bart.

PRESIDENT OF THE ROYAL SOCIETY.

I Addreſs myſelf to you as a Patron and well-known encourager of all uſeful Arts. Far from apprehending myſelf fit to be ranked in that claſs, as an Author, I have the greater reaſon to make you, Sir, my acknowledgments for condeſcending to accept of this Dedication; and your doing it with a complacency and eaſe, natural indeed to you, is what adds weight to the obligation: Since I have thereby the pleaſure of offering to the Public a Treatiſe, under your protection, on a ſubject that every man ought, at leaſt in ſome meaſure, to underſtand.

That you, Sir, may continue long of the number of thoſe great and exalted ſpirits, who ſeem to be born for the good of mankind, is the ſincere and ardent wiſh of,

S I R,

Your moſt obliged,

and moſt humble Servant,

JOHN READ.

KNIGHTSBRIDGE,

Feb. 2, 1792.

PREFACE.

"WHAT CAN WE REASON BUT FROM WHAT WE KNOW?"
POPE.

EVERY effort towards the elucidation of an important phenomenon, carries its apology along with it; otherwiſe I ſhould be fearful of offending that critical nicety, which in our age lays ſo much ſtreſs upon words more than matter. Purſuits in Electricity have of late been more languid than formerly—not that the ſubject is exhauſted, but that other matters have engaged the philoſophic world. If I preſume to renew the enquiry, and add a few plain facts in a *plain way*, I hope it will be forgiven.

Atmoſpherical Electricity has, in my opinion, been much leſs an object of philoſophic enquiry than it deſerves; but more particularly ſo, as it relates to Botanical Meteorology. Though we have been tolerably inſtructed in the identity of lightning and electricity, and exhibit in our experiments, many ſtriking analogies; yet the perpetuity of Atmoſpherical Electricity, has not to my knowledge been aſcertained by any writer on electricity before. Obſervations on this property have been my ſtudy and amuſement for ſome years; and, I hope the ſimple narrative I have given of them in the following work, will have novelty in it at leaſt.

The Electrical Experiments on Combuſtion, I alſo preſume to think are new: they have to me thrown conſiderable light on that controverted ſubject, the riſe of vapour, as well as on the ſuppoſed affinity between electricity and culinary fire.

The Doubler of Electricity has made its appearance in the Philoſophical Tranſactions; it is an inſtrument of great curioſity. I have taken ſome pains to improve this inſtrument, but conſiderably more with a view to aſcertain its real powers and properties, and have applied them ſucceſsfully in explaining various phenomena reſpecting Atmoſpherical Electricity.

Spontaneous Electricity is no new diſcovery; many eminent Electricians have in their works juſt touched upon it, without forming any definite opinion, or applying their obſervations to elucidate the phenomenon of Lightning. I have called in its aid, or rather fixed it as a baſis, whereon to eſtabliſh the following Theory on Lightning; and which, I truſt, will afford ſome relief, eſpecially with reſpect to the vaſt quantity of it.

Atmoſphérical Electricity will be found, when purſued experimentally, a field full of pleaſing objects, and which ariſe from cauſes ſeemingly the ſlighteſt imaginable. Scenes like theſe, in which we ſee a gradual riſe and progreſs in things, always exhibit a pleaſing ſpectacle to the human mind. Nature, in all her delightful walks, abounds with ſuch views.

As to myſelf, I find it abſolutely impoſſible to produce a work on this ſubject that ſhall be any thing like complete. My original deſign of making experiments and memorandums, was only for my own inſtruction and amuſement; nor had I the leaſt idea of communicating any part of them to the public. But ſeveral perſons converſant in electricity, have expreſſed a wiſh, that the following Eſſay might be preſerved. From a genuine love of ſcience, and of mankind, I immediately communicate to the curious, in this branch of Philoſophy, whatever has occurred in my inquiries. He who does not fooliſhly affect to be above the failings of humanity, will not be mortified, when it is proved that he is but a man; this will ever be the caſe in the progreſs of natural ſcience, ſo long as the works of God are like himſelf, infinite and inexhauſtible: how few ſteps we take therein before we approach that veil of nature which man cannot remove.

I cannot help beſpeaking the Reader's candour with regard to my own inability, and want of learning for ſuch a work as this; and hope, that he will be induced to make ſome favourable allowances for any errors which he may diſcover, and kindly correct them for himſelf. Permit me, therefore, to conclude this Preface, with that humble *requeſt* of the illuſtrious Sir Iſaac Newton, which, although in him it might well have been ſpared; yet a more modeſt one cannot well be exhibited for the moſt defective performance, even for this of mine.

" I heartily beg that what I have here done, " may be read with candour; and, that the de- " fects I have been guilty of, upon this difficult " ſubject, may be not ſo much reprehended as " kindly ſupplied, and inveſtigated by new en- " deavours of my readers *."

---

* Preface to his Principia.

CONTENTS.

Page

Chapter I.—*Containing a ſummary view of ſome Experiments on Spontaneous Electricity,* - - - - 1

Chapter II.—*Experiments and Obſervations on Heat, tending, to prove, that heat, ſimply conſidered, acts on the electricity, both naturally and artificially applied,* 11

Chapter III.—*Containing ſome general Laws, ariſing from Experiments and Obſervations on Atmoſpherical Electricity,* - - - - - - - - - - 18

Chapter IV.—*A Deſcription of the Spectacle Doubler, which, by the turning of a winch, produces ſpontaneouſly, without friction, the two ſtates of Electricity. To which is added, Experiments and Obſervations, to prove, that the ſpontaneous Electricity of the Doubler is obtained from the common electrified vapour ſuſpended in the air,* - - - - - - - - - - - 25

Chapter V.—*Containing ſome general Obſervations on Lightning,* - - - - - - - - - - 34

Chapter VI.—*Containing Experiments and Obſervations, tending to prove, that every Flaſh of Lightning conſiſts of poſitive and negative Light; and which ruſh into union from two oppoſite directions,* - - - 39

Chapter VII.—*Further Obſervations and Conjectures on the Phenomena of Lightning,* - - - - 58

Chap-

CHAPTER VIII.—*Containing ſome Experiments and Obſervations on the Leyden Bottle,* - - - - - - 75

A LETTER *on Electricity to Mr. A. Walker, Lecturer on Experimental Philoſophy,* - - - - - - 85

REMARKS *on Dr. Peart's late Book on Electricity,* - - 95

A JOURNAL *on Atmoſpherical Electricity, read at the Royal Society, April* 14, 1791, - - - - - - 103

SOME *of the Experiments illuſtrated with a Copper-plate,* - - - - - - - - - - - 160

ADVERTISEMENT.

The Author begs to inform ſuch of his Readers as are unacquainted with the nature of printing, and may, therefore, think the price of this Book rather high, that it is occaſioned by the great expence of the Journals.

Spontaneous Electricity.

CHAPTER I.

Containing a Summary View of Spontaneous Electricity.

EXPERIMENTS to produce electricity, without the aid of friction, has of late years, been diverſified and combined in almoſt every method poſſible; a particular account of all the circumſtances which have attended theſe experiments would be too prolix and tedious. I ſhall therefore content myſelf with a ſhort recital of ſeven or eight of the main ones; and then make a few conciſe obſervations, that will naturally ariſe, and which I cannot do better than by writing the narrative nearly in the order of time in which the appearances occurred.

EXPERIMENT I.—*By warming the electric.*—I know of none prior to thoſe made with the Tourmalin. The electricity of this ſtone is excited by heating it, and is ſo ſenſible, that Mr. Wilſon found that removing the Tourmalin from one room to another, in which there was ſome difference of heat, was ſufficient to excite it. Mr. Canton, obſerved, that the Tourmalin emits and abſorbs the electric fluid only by the increaſe or diminution of its heat.

Notwithſtanding the care and attention given to this ſtone, by theſe two eminent electricians; yet, one of its properties eſcaped their obſervation, and was reſerved for the penetrating ſagacity of Dr. Prieſtley, which is this, "that the *ſame flat ſide* of the ſtone, would often be "ſtrongly poſitive and negative at the *ſame time*[*]." Conſequently the middle part of that ſide of the Tourmalin, between the two electricities, muſt be in its natural ſtate.

Experiment II.—*By the liquifaction of electric ſubſtances.*—Mr. Wilke melted ſulphur in an earthen veſſel; then, letting it cool, he took out the ſulphur, and found it ſtrongly electrical. He then melted ſulphur in glaſs veſſels, whereby they both acquired a ſtrong electricity; the glaſs was always poſitive, and the ſulphur negative.

Experiment III.—*By the evaporation of water.*—The methods uſed by Mr. Volta, and other electricians, to turn water into vapour, in order to excite and examine its electricity, have been various. Several years ſince, I ſaw

---

[*] See Dr. Prieſtley's Hiſtory of Electricity, page 712.

Mr. Volta obtain a very ſmall quantity of electricity, from the fumes of a mixture of water, oil of vitriol, and filings of iron.

Experiment IV.—From a hint received from Mr. Volta, I made the following ſimple experiment, which any body may repeat with eaſe, who has glaſs or wax to inſulate a veſſel. I collected into an earthen veſſel about a pint of red-hot cinders, which was placed upon a glaſs ſtand; acroſs the top of the veſſel was laid a braſs wire, with two fine linen threads ſuſpended at one end of it, which were to ſerve for an electrometer; a tea-cup full of water was then thrown on the red-hot cinders, and the threads inſtantly diverged two inches with negative electricity.

The method of performing this fine experiment, by the Reverend Mr. Bennet, F. R. S. is much more neat and elegant. His gold leaf electrometer being well adapted to the performance of experiments of this kind. He places a metallic cup upon the cap of his electrometer, with one or two red-hot cinders in it, and then lets fall a ſpoonfull of water upon the hot cinders, and the gold leaves ſoon open with negative electricity.

Experiment V.—But theſe two methods of performing the ſame experiment, only extend to the ſtate in which the apparatus is at the time when the vapours aſcend, and then it is always found electrified negatively. Conſequently it was natural to conjecture, that the aſcending vapours muſt have abſorbed, while they were forming, a quantity of the electric fluid, and therefore muſt be in a poſitive ſtate; which has ſince been verified by my own experiments.

ments. The method I purſue to verify it is, by inſulating a large hollow tin cone, containing about four ſheets of tin plates, with many yards of ſmall wire coiled up within it: one end of the wire is made to extend from the apex of the cone, (which is open) to a very ſenſible electrometer. The cone and wire collect and condenſe the aſcending electrified vapour, as it quits the inſulated veſſel placed under it, which always electrifies the electrometer connected with the cone, poſitively; and the other electrometer, which was connected with the veſſel whence the vapours aroſe, negatively.

Experiment VI.—*By combuſtion.*—This may be conſidered as an evaporation of the higheſt degree. That bodies paſſing from a ſolid or fluid ſtate, into vapour, give unequivocal proofs of poſitive or negative electricity being combined with them in that ſtate, is now evident. I have burnt ſeveral different ſubſtances in inſulated veſſels, under the tin cone deſcribed in the preceding experiment. The conſequence was that the cone became perceptibly electrified. One of the ſubſtances conſumed in the aforeſaid manner, was dry wheat ſtraw, by which the cone became weakly electrified, poſitively.

Experiment VII.—Having by me a quantity of roſin and bees wax melted together, but in what proportion to each other I have entirely forgotten, I placed about half a pound of it in an iron ladle, and made it ſmoaking hot on a coal fire: the ladle was then taken from the fire, and placed on the glaſs ſtand under the cone, and a piece of lighted paper was thrown into it, which put the ſmoaking hot compound in a blaze; which ſoon gave evident ſigns of the preſence of the electric fluid. The electrometer connected with the cone, was electrified negatively; the threads opening near two-tenths of an inch. The force of the fire having ceaſed, and the cone cooling pretty faſt, I was agreeably ſurprized to obſerve the threads opening ſtill wider, ſo that in a few minutes, they were ſtationary at near half an inch apart.

EXPERIMENT VIII.—About a quarter of a pound of ſhellac, was placed in the iron ladle, and made ſmoaking hot on the fire; the ladle was then taken from it, and placed on the glaſs ſtand, under the cone, and the hot lac was put in a blaze with lighted paper, the threads opened negatively by the electrometer connected with the cone.

EXPERIMENT IX.—A brown earthen diſh was placed on the glaſs ſtand, under the cone; in the diſh was laid a handful of dry hay, and inflamed by means of lighted paper, then more hay was thrown in, to keep up the flame a little longer; which cauſed the threads of the electrometer, connected with the diſh, to open poſitively; but that connected with the cone ſhowed no ſigns of electricity. In this, and the preceding two experiments, the charge increaſed quickeſt immediately after the blaze had ceaſed.

EXPERIMENT X.—A chafing-diſh filled with blazing coals, was placed on the glaſs ſtand under the cone, and the fire was raiſed by means of a pair of bellows; the electrometer connected with the chafing-diſh was electrified poſitively, and that with the cone was juſt ſenſibly negative. I then repeated this experiment, to ſatisfy myſelf more perfectly, but with leſs ſucceſs than before, for no electricity appeared in the cone, and ſcarce any in the chafing-diſh, which however ſeemed to be poſitive.

Experiment XI.—Every part of the apparatus remaining as in the preceding experiment, and the embers in the chafing-diſh being red-hot, a lump of ſulphur was dropped into them, but I quickly found the noxious effluvia too ſuffocating to allow me to attend to the operation. When they were a little ſubſided, I approached near enough to make an obſervation, and found that both electrometers ſhowed ſigns of negative electricity.

However copious the diſcharge of the electric fluid may be, by combuſtion, the quantity obſerved in the preceding experiments is very ſmall. I conjecture that it may be owing to an intimate union ariſing from a ſtrong affinity that there is between flame, and the electric fluid; and that the portion of fluid detached from the burning body in our experiments, is not at all ſufficiently condenſed to quit a better conductor for a worſe. As to the ſmoke, which is unavoidably raiſed by combuſtion, it can by no means affect the experiments, becauſe ſmoke near the burning body, forcibly reſiſts the paſſage of the electric fluid. Flame on the contrary greedily abſorbs it, and carries it away; and therefore, how any, even the ſmalleſt quantity of the electric fluid, ſhould be detained by the apparatus, is to me very unaccountable. And to obtain even that little portion, which it is poſſible to collect from the flame of the combuſtible ſubſtance, depends more upon the goodneſs of the inſulation of the apparatus, than upon any other circumſtance whatever. The two following experiments evince theſe aſſertions on flame and ſmoke.

1ſt. Let a bottle (prepared for the Leyden experiment) be fixed to the end of a metallic rod a foot long, which will ſerve as a handle. Charge the bottle, and hold it by the metallic rod, and paſs it with a quick motion through a column of flame, raiſed from any combuſtible ſubſtance. The conſequence is, that the electrical equilibrium of the bottle will be as completely reſtored by the flame as if it had been plunged into water.

2d. Vary the experiment, by paſſing the charged bottle through a column of ſmoke, inſtead of flame; and it will come out of the ſmoke with its electric charge undiminiſhed.

It is neceſſary in both experiments, to paſs the bottle with a quick motion. In the former, to prevent the bottle from breaking; and in the latter, to avoid as much as poſſible the *ſoot* of ſmoke from fixing itſelf on the uncoated part of the bottle, which would defeat the experiment, becauſe *ſoot* ſeparated from ſmoke, is a *conductor* of electricity.

Theſe facts ſeem to have ſome connexion with another mentioned by Sir William Hamilton, in his accurate and circumſtantial deſcription of the eruption of Veſuvius in 1779. Which eruption was evidently accompanied with great quantities of electricity, which flaſhed among the flames, and in the loweſt part of the ſmoke of the burning mountain, but could not penetrate the column of ſmoke ſuſpended over the flames, and thereby aſcend into the higher and cloudy atmoſphere. He deſcribes it thus:

“Puffs of black ſmoke ſucceeded one another haſtily, and accompanied the red-hot, tranſparent, and liquid lava, within which ſmoke I perceived a bright, but pale, electric fire, briſkly playing about, in zig-zag lines. This black cloud of ſmoke was charged in its courſe with electrical matter, which darted in ſtrong and bright zig-zags, juſt like thoſe deſcribed by Pliny the younger in his letter to Tacitus. This volcanic lightning, however, very rarely quitted the cloud, but uſually *returned* to the great column of *fire* towards the center of the volcano, from whence it originally came.”

Sir William Hamilton might eaſily imagine that the volcanic lightning was connected with the lower ſurface of the column of ſmoke, becauſe there the greateſt efforts of the highly electrified flames would be exerted, in order to penetrate and paſs through it; conſequently its operations muſt be there moſt conſpicuous.

EXPERIMENT XII.—*Hot air is not a conductor of electricity.*—It is inconteſtibly proved, that glaſs heated beyond a certain degree, is a conductor of electricity. But it has not yet been diſcovered in what manner heat in glaſs contributes to that effect. It has been alſo commonly ſaid, that *hot air* conducts electricity. With a view to aſcertain this matter the following experiments were made. To one end of a long piece of wood (which ſerved as a handle) was fixed a glaſs rod, fifteen inches long; to the remote end of the glaſs was fixed a pith-ball electrometer. Having electrified the balls, I held them by the wood handle, and projected them into a large oven, immediately after the fire was drawn out of it; the conſequence was, that when I performed the operation ſlowly, the balls loſt their electricity; but that when done quick, with as little delay as poſſible, their electric charge was not diminiſhed. The loſs of electricity in the firſt caſe was found to have eſcaped along the glaſs into the wooden handle, and ſo to the earth, owing to the great heat the glaſs rod had acquired, by which it became a conductor of the fluid; for until it had cooled a little the balls could not be charged again.

I ſhall lay before the reader one circumſtance more, becauſe it may tend to throw light on what degree of heat the oven was in, at the time the obſervations were made. The baker having pointed out to me the hotteſt part of the oven; with a quick motion in and out, I plunged the electrified balls into that part of it, by which one thread and ball was burnt off, but the remaining ball ſhewed that it ſtill retained its electric charge, becauſe it was ſtrongly attracted on the approach of my finger. I did not chooſe to hazard Farenheit's thermometer, to aſcertain the heat of the air in the hotteſt part of the oven, but being placed near its mouth it roſe to 102°.

An apparatus for collecting the electricity of the atmoſphere, in order to aſcertain its ſtate, and the quantity of fluid, in all ſorts of weather, by day or by night, (which generally conſiſts of high pointed and inſulated conducting rods, connected with an electrometer &c.) may juſtly be conſidered as an inſtrument daily producing ſpontaneous electricity, which it ſimply receives from the aqueous vapours ſuſpended in the atmoſphere. The deſign of its firſt contrivers was principally to collect into bottles ſome lightning, during thunder ſtorms; but they ſeemed to have had no idea of there being ſome electricity, conſtantly preſent in the aqueous vapours.

The common and revolving doubler of electricity, always produces the electric fluid without friction or previous communication. Thence it is that ſuch productions are termed ſpontaneous. The great powers of the revolving doubler are apparent; which from its peculiar manner of augmenting otherwiſe inſenſibly ſmall quantities of electricity, even to viſible ſparks; ſeems to aſtoniſh the beholder.

Atmoſpherical electricity, ſimply conſidered, is ſtrictly ſpontaneous, as ſome of the foregoing experiments and obſervations tend to illuſtrate and confirm. I now find no difficulty in the obtaining of it at all times, as it is always obſervable, more or leſs, even during temperate weather, where no ſeeming irregularity reigns in the atmoſphere, ſuch as conſtitutes thunder-guſts, which ſhall by and by be briefly conſidered. The difficulty accompanying the inveſtigation of atmoſpheric electricity, was formerly owing in ſome degree to the want of means ſufficient to obtain the electricity in certain ſorts of weather; this is now removed, and the means, and manner of doing it, is here I truſt, made plain and eaſy to the reader.

During moderate weather, the aqueous vapours ſuſpended in the air, are generally found by experiment, to be in a ſtate of poſitive electrification, to the height my pointed rod reaches; which is ſixty-one feet; how much higher the poſitive ſtate of the electric fluid extends, I am not certain. The intenſity of the electrified vapour within this height, gradually decreaſes as it approaches nearer the ſurface of the earth. Yet I doubt, whether this is a real fact or only a circumſtantial effect. For in this caſe it may be, that the nearer all things approach to an equal intenſity, the uſual ſigns of the preſence of the electric fluid muſt of courſe grow leſs, and become extinct. However, I have ſometimes found the electrified vapour, within ſix inches or leſs of the earth's ſurface, negative; when at the ſame time, at a conſiderable greater height, it was poſitive. But at what height the neutral or rather natural ſtate of the vapour happens to be between the two electricities, ſo circumſtanced, is ſo nice a point, that I could never accurately determine it. At other times, when the vapour is rather more than commonly electrified, its poſitive ſtate ſeems to take place on the ſurface of the earth itſelf; but in this caſe alſo, the intenſity of the fluid increaſes as its diſtance from the earth increaſes.

CHAPTER II.

Experiments and Obſervations on Heat.

WE conſider the ſun as the primary ſource of heat upon the ſurface of the earth, and the atmoſphere; without this, all the bodies upon our globe would doubtleſs grow rigid, lifeleſs, and fixed. Hence I conſider heat to be the immediate cauſe of motion to the electric fluid, contained in the earth and waters; by agitating the corpuſcles of natural bodies, and continually ſtirring or exciting ſuch a degree of motion in the ſmall particles of matter as is ſufficient to excite their natural electricity. The truth of this remark is eſtabliſhed upon various effects, and I think, by the before-mentioned experiments, on ſpontaneous electricity.

Whether we conſider heat as ſolar or ſubterraneous, or both, as relative to the electric fluid, it matters not. Becauſe it appears both by nature and art, that generally a certain degree of heat is neceſſary to diſlodge the electric fluid contained in the pores of bodies. It is well known that *heat* acts more powerfully on *water*, than on *air*; and many other natural bodies, "for that the ſame degree of heat, which rarifies air two-thirds, will rarify water near fourteen thouſand times*." Thus in winter when the atmoſphere appears cold to our bodies, it ſtill contains a degree of heat ſufficient to change water into vapour, though that degree of heat can ſcarcely affect air.

Heat communicated to water, cauſes a ſeparation beyond the ſphere of corpuſcular attraction, by which means the volatile particles will fly off at the ſurface, in the form of vapour: when by heat the particles are ſeparated from their contact, their repulſive force grows ſtronger, being alſo aided in their riſe when in air, by the well known repulſive force of the electric fluid, which I ſuppoſe, has even no weight at all, and which is naturally connected with every particle of water, ſo that the ſame ſhould be expanded into a very large ſpace, by becoming electrified vapour, may poſſibly take up more than ten thouſand times the room it did in the form of water; having thus become ſpecifically lighter than air, muſt neceſſarily be buoyed up into the atmoſphere, and there form the clouds, &c. If the vapour in its egreſs, be at all viſible, and having attained the height of five or ſix inches of inſulation in air, it will evince by proper inſtruments that it is permanently electrified.

---

* Philoſophical Tranſactions, N° 407.

It has already been ſaid, that the vapours ſuſpended in the air, are generally found to be in moderate weather, electrified poſitively. If it be juſt to transfer the application of the facts, which ariſe from artificial vapour, raiſed by means of fire, to vapour raiſed naturally, we cannot avoid concluding, that natural vapour muſt be in a poſitive ſtate the moment it quits the earth and waters; as the experiments on evaporation of water abundantly confirm.

Moreover heat and water are conductors of electricity. And their being always combined in vapour, muſt increaſe their capacity for retaining electricity, ſo that water in its rarified ſtate, requires, and will abſorb more of the electric fluid, than when in its denſe ſtate as water: and the vapour by riſing into cooler air, will be gradually condenſed more and more, which muſt neceſſarily *increaſe* the *intenſity* of its poſitive charge. Thus we ſee, how heat and cold may be conſidered as a general, if not the ſole cauſe, why we almoſt always find by experiment, the vapours ſuſpended in the atmoſphere, electrified poſitively.

That heat, by its power of penetrating and expanding all groſs bodies, and thereby weakening the attractive force of their component particles, muſt by its mode of vibration amongſt the conſtituent parts of matter, move or excite the electric fluid, lodged within them; nature, as well as art, ſeems to afford ſufficient proof. Elſe why more lightning in ſummer than in winter? Are not the different degrees of heat between thoſe ſeaſons, one, if not the main cauſe? That heat ſimply conſidered is poſſeſſed of the power of conducting the electric fluid, Dr.

Prieſtley obſerves. "From theſe experiments, (*viz.* on heat) and thoſe on ice, I concluded, that fluidity, as ſuch, contributes nothing to the conducting power of ſubſtances, ſeparate from the *heat* which makes them fluid." As may be ſeen more at large in his excellent Hiſtory of Electricity, SECTION IV, on the Conducting Power of Subſtances, page 609.

Dr. Prieſtley obſerved, "that a red hot poker placed between two braſs knobs, one communicating with the inſide, and the other with the outſide of the charged battery, promoted the diſcharge at about twice the uſual diſtance. *Both ſides* of the hot poker were *marked* with an imperfect *circle.*

"He brought the flame of a candle between the two braſs knobs, and obſerved, that as the flame advanced towards them, it began to be put into a quivering motion, exceedingly quick, and was ſtrongly drawn *both ways* towards each knob, leaving the wick bare at the top; and as ſoon as the flame was quite between the knobs, the battery diſcharged at once, at the diſtance of three inches and an half." He further adds that, "this is a very fine experiment. The interpoſition of the flame between the two braſs knobs is like putting fire to a train of gunpowder, which explodes immediately."

I would farther add by way of inference drawn from both the above mentioned experiments, which agree well with my ideas, that they afford ſigns equally deciſive of two oppoſite currents, running into one another, in the middle of the interrupted ſpace, within the circuit of communication, between the ſides of the battery, which however, I ſhall endeavour to diſcuſs more fully in the ſixth chapter.

That heat ſimply conſidered, acts immediately on the natural electricity of the Tourmalin (and a variety of other gems) is well atteſted in the Hiſtory of Electricity; and has been noticed in the firſt page of this work. That it becomes electrified, merely by heating and cooling, without friction, has been verified by ſeveral eminent electricians. I have obſerved in the electricity of fogs, that when a fog ſuddenly became thick and dark, the intenſity of its electric charge was ſuddenly increaſed alſo; on the other hand, when a fog begins ſuddenly to ſubſide and clear up, the electric ſtate of its remains is but weak. But I never obſerved the electricity of a fog change in kind. I ſuppoſe that ſudden changes in the denſity of the fog, is owing to a quick change of heat and cold; however, thoſe ſudden changes in the intenſity of their electricity, generally reminded me of Mr. Canton's following obſervation on the Tourmalin *viz.* That the electric power of the Tourmalin does not depend on any particular degree of heat, but that the circumſtance of *changing* its degree of heat, gives electricity to this *ſtone.*

Heat acts upon the electricity of bodies artificially electrified. Mr. Canton, procured ſome thin glaſs balls, of about an inch and a half diameter, with ſtems or tubes of eight or nine inches in length, and electrified them, ſome poſitively on the inſide, and others negatively, and then ſealed them hermetically. Soon after he applied the naked balls to his electrometer, and could not diſcover the leaſt ſign of their being electrified; but holding them before the fire, at the diſtance of five or ſix inches, they became ſtrongly electrical; and more ſo when they were cooling. Heating them frequently, he found, would ſenſibly diminiſh their power; but keeping one of them under water a week, did not appear in the leaſt to impair it. Some of his balls retained their virtue upwards of ſix years, but in a leſs degree.

I have ſucceeded in the ſame experiments, or I would not have mentioned them here. Becauſe Dr. Prieſtley failed in his attempt to repeat them after Mr. Canton. The Doctor's failure was owing, as he himſelf juſtly ſuppoſed, to his glaſs balls being too thick. There is, however, one circumſtance worth mentioning, which accompanies theſe experiments, and which Mr. Canton ſeems to have overlooked, as he has not mentioned it, *viz.* that the electricity produced by heat, on the outſide of the glaſs balls, is always the ſame in kind with that within them. Conſequently, frequent heating the balls, muſt leſſen their electric charge; and is a ſtriking proof of the permeability of *thin warm* glaſs to the electric fluid.

I ſhall add only this one experiment more on heat. The indefinitely ſmall remains of electricity, in a diſcharged Leyden bottle, are put in motion by the heat of the hand only. It was diſcovered in the following manner. I was ſhowing a gentleman the power, and utility, of Volta's Condenſer of Electricity. In order to which a Leyden bottle was charged and then diſcharged, by touching its coated ſides with a diſcharging rod. It now appeared to be deprived of all its electricity; yet if I held it by the coating, and touched with the knob of it the metal plate of the condenſer (placed upon an imperfect conductor) and held them in contact a few ſeconds of time, then removed the bottle, and took up the metal plate by its inſulating handle, and preſented it to a ſenſible electrometer, the electricity was ſtrong enough to enable me to aſcertain its quality. But theſe beautiful effects diminiſhed by repetition; and I repeated the experiment until no electric ſigns appeared in the *condenſer*. However, while we were talking the matter over, I ſtill held the bottle in my hand; and after a long interval of time, from our laſt trial, I repeated the operation once more; and, to our aſtoniſhment, we found the bottle ſtill ſtrongly electrical. This new revival of the electricity we could attribute to nothing but the diffuſive warmth of my hand, acting on the electricity of the bottle. This ſet us to work again, and to try the bottle by turns in a warm and cold ſtate, and we found that our conjecture of the cauſe was confirmed by repeated trials.

I now ſet by the bottle all night, in its preſent ſtate of electricity, and next morning I repeated the operation with it in a cold ſtate, and could not diſcover the leaſt ſign of its being electrified; I then graſped it in ſeveral places on the coating with my hands, till it became warm, and then repeated the experiment in the uſual way, and on preſenting the plate of the condenſer to an electrometer, it charged it pretty ſtrongly. I repeated theſe trials, with the ſame bottle, but without any additional charge, three ſucceſſive mornings, and the effect was nearly the ſame.

CHAPTER III.

Containing ſome general Laws ariſing from Experiments and Obſervations on Atmoſpherical Electricity.

1. THE electricity of the atmoſphere is invariably of the poſitive kind in moderate weather, both in ſummer and winter, day and night, during the ſunſhine, or in gloomy weather. It ſhould ſeem, therefore, that the electricity of the atmoſphere is eſſentially poſitive.

2. In foggy or thick weather, without clouds, if the air is at the ſame time ſharp or froſty, the electricity of the atmoſphere is generally vigorous; but fog accompanied with warm air, and going to reſolve into ſmall rain, is ſure to afford none, or but very weak ſigns of electricity, yet they are generally poſitive.

3. Warm moiſt air is never ſtrongly electrical. But the quantity of electricity is by no means proportional to the quantity of moiſture in the air, and it is often the contrary. An intenſe electricity depends more on the quality, than on the quantity of moiſture.

4. In dark cloudy weather, without rain or ſtrong winds, atmoſpheric electricity, is generally governed by the ſame laws, as in more clear ſerene weather, and is therefore poſitive.

5. Rain after a continued ſucceſſion of moderate weather is always electrified negatively; and very intenſely ſo, if the ſhower be heavy, and its drops large. Such a ſhower of rain commonly becomes poſitive about the middle of it, after that ends as it began, negative; but if otherwiſe, it is from the beginning to the end of it negative. Other rains are not ſo regular.

6. When rain falls plentifully without a ſtorm, its electricity is not ſo varied in kind nor quantity as when accompanied with a briſk wind, and black clouds.

7. Storms of wind, accompanied with heavy black clouds, rain, hail, or ſnow, are always very intenſely electrified. But the intenſity of the electricity during ſuch ſtorms is variable. Thus in ſtormy weather we ſee the electricity ſtrong, then weak, and in a moment after riſe to its former ſtrength; one inſtant poſitive, and the next negative. I have ſeen theſe changes ſucceed ſo rapidly, that I had ſcarcely time enough between the intervals to note them down.

8. The atmoſphere is generally but weakly electrified during high winds with a clear ſky; and during ſtrong eaſterly winds with or without a clear ſky. Strong gales of wind ſimply conſidered, always diminiſh the intenſity of atmoſpherical electricity let them blow from what point of the compaſs they may.

9. The intenſity of atmoſpheric electricity is augmented by *cold*. This is very eaſily obſerved in foggy weather. And from the numerous obſervations which I have made

on this ſubject, I am led to a belief, that this increaſe of electricity by *cold*, and the contrary, is a general law, and takes place in almoſt all the atmoſpherical phenomena; ſo that there is an increaſing progreſſion from the ſmalleſt ſigns of electricity, uſually obſerved in warm ſmall rain, to rain with large drops, and ſo on to ſnow and hail; for hail ſhowers of all others are the moſt intenſely electrified. There are, however, ſeveral other circumſtances which concur to the production of theſe effects, ſuch perhaps as the height whence the meteors deſcend, &c.

10. During a courſe of ſerene weather, it is eaſily obſerved that atmoſpherical electricity is ſubject to a flux and reflux, which cauſes it to increaſe and decreaſe twice in every twenty-four hours. The moments of its greateſt ſtrength are generally after the riſing, and a little before and after the ſetting of the ſun, and thoſe of its greateſt weakneſs are from mid-day to about four o'clock, and midnight.

The cauſe of this periodical flux ſeems obvious; for as ſoon as the ſun warms the earth where the obſervation is made, and in proportion as it riſes above the horizon, the atmoſpheric electricity augments, becauſe the vapours which then riſe carry the electric fluid from the earth into the atmoſphere; but when the ſun has attained the meridian, the heat increaſes in a greater proportion than the evaporation, the air becomes dry, and will therefore hardly tranſmit the electricity. The high pointed rod will now exhibit weaker ſigns of electricity, there being but little moiſture in the lower region of the atmoſphere. But when the ſun is near ſetting, the air grows cool, becomes

comes humid, and tranſmits more abundantly the electricity of the earth, which gradually increaſes in its intenſity; the electrification of the rod will now riſe again with the evening dew, till two, three, and ſometimes four hours after ſun-ſet; and then, as I ſuppoſe, it muſt gradually diminiſh to the next morning *. But is never quite deſtroyed if the inſulation of the rod is not injured by the moiſt night air.

In purſuing the conſideration of this ſubject it appears that the electricity of the atmoſphere (the conſtant exiſtence of which has been abundantly proved by experiments) and its fluctuations, are principally depending on the viciſſitudes of heat and cold, and upon the aqueous vapours; but there are ſeveral other phenomena concerned in it. Thus the regular rotation of the heat occaſioned by the diurnal motion of the earth, the dryneſs or moiſture of the atmoſphere in particular ſeaſons, and various other phenomena, muſt naturally affect its periods of increaſe and diminution. And though thoſe periods are ſubject to ſome variety in point of time, yet upon the whole the facts mentioned above are indiſputable.

The electricity riſes inviſibly from the earth, concealed in the aqueous vapour; and as the vapour aſcends higher and higher into cooler air, it becomes more condenſed; by which the electricity which it contains will become

---

* I have ſaid " I ſuppoſe," becauſe I never quite ſat up all night to prove it; but from a great number of obſervations I have more reaſon to ſuppoſe it muſt be ſo than the contrary.

more condenſed alſo*, in ſo much that it will now diſplay its energy, and in whatever direction it moves it is ſure to move actively, animated with a penetrating and expanſive force; for in this ſtate proper inſtruments will eaſily accumulate and detain it, ſo as to render it viſible.

I have no idea, much leſs ſuppoſe, that any, even the leaſt quantity of electricity does ever come from air itſelf; for there is reaſon to think, that air as air, independent of the other ſubſtances, is unable to furniſh any particle of this fluid; and I conjecture that pure air and electricity are actually incapable of uniting; and therefore it is that air is never known to attract, abſorb, nor conduct electricity, but in proportion to the conducting ſubſtances with which it happens to be occaſionally mixed: nor is air excitable of electricity by any means that is yet known; therefore air does not appear to be either an electric or a conducting body.

It is in conſequence of theſe peculiar properties of air that it is found to inſulate the electric fluid more perfectly than any other ſubſtance; that is to ſay, air in even that ſtate of purity which is common to it in dry ſerene weather. Had not air poſſeſſed theſe properties the exiſtence of the electricity could never have been diſcovered. Hence it is alſo manifeſt, that the phenomena of lightning and thunder could not have happened in nature.

---

* It is well known, that if equal quantities of electricity be imparted to two unequal inſulated conductors, the electricity on the leaſt ſurface will become more intenſe than on the largeſt. Electrified vapour is alſo ſubject to this law.

In the inveſtigation of theſe matters it is almoſt impoſſible for a man to attend every moment to them. It is therefore neceſſary to deduce the law from the general correſpondence of facts, and upon theſe grounds I hope that the aſſertion of the perpetuity of atmoſpherical electricity may not be conſidered as too precipitate and unwarrantable.

Artificial electricity is ſoon produced, and it is as ſoon diſſipated and loſt. But natural or atmoſpherical electricity is univerſal and conſtant, and is incapable of being diſſipated or deſtroyed. For, when ever I ſcrutinize this matter, whether I do it by day or by night, I always find a quantity of electricity ſufficient to aſcertain the kind which at any time is predominant in the atmoſphere; and which for its conſtancy and univerſality may properly be deemed an electrical atmoſphere within our aerial atmoſphere. It is probable that theſe two extremely ſubtile and elaſtic fluids may have ſome unknown dependence on each other, either for their own formation, or their general beneficial properties to the reſt of all created beings.

I beg leave here to relate, in concluding this chapter, an obſervation I have made upon the electricity of winds which have (by the public at large) been deemed *unhealthy.* My enquiry was only whether ſuch winds contained much or but little of electricity. My attention and remarks on this matter have been repeated with care.

A wind prevailed during the latter end of March, and the greateſt part of the month of April 1790, which was univerſally deemed by the people to be unhealthy. This wind was eaſterly, and blew with a briſk ſteady gale, rather ſharp and piercing. It contained but very little electricity; the quantity was even ſo ſmall that I was often obliged to exert my utmoſt abilities to obtain enough of it to aſcertain the kind, which I often could not do except I added to my exploring rod a lighted *torch.** The people were generally more ſickly than at other times, and their malady was attributed to the unwholeſome eaſt wind. Even vegetables, during this wind, did not grow but ſeemed to be in a ſickly dying condition. I think there is ſufficient reaſon to conclude, that dry eaſterly ſtrong winds are more barren of the electricity than any other.

There were within the courſe of the above mentioned month of April, about eight ſmall ſhowers of rain, and two of ſnow; all of which were moderately electrified.

---

* Flame exceeds abundantly ſharp pointed wires in the powers of collecting atmoſpherical electricity; it has never yet failed me, and I find that its collecting powers increaſe with an increaſed quantity of flame.

CHAPTER IV.

A Deſcription of the Spectacle Doubler, which, by the turning of a winch produces ſpontaneouſly, without friction, the two ſtates of Electricity.

THE figures 3 and 4 repreſent the inſtrument in every particular a fourth part of the dimenſions of the original. Fig. 3 repreſents the inſtrument ſupported on a glaſs pillar. It conſiſts of the following parts: Two fixed plates of glaſs (or of any other ſubſtance) A and C, are ſeparately inſulated and diſpoſed in the ſame plane, ſo that a revolving plate glaſs B may paſs very near without touching them. Each of theſe plates has a ſmall hole drilled in the middle, with a diamond drill, in which pieces of braſs are riveted, tapt with a female ſcrew on their back part, which receives ſcrews made with riſing knob heads, by which the plates are ſcrewed in their places. The other parts may be diſtinctly ſeen in fig. 4. The ſhaded parts repreſent metal, and the white repreſent glaſs covered with ſealing-wax, except the plates A B C. O N is a braſs axis, that carries the revolving plate B, paſſing through the piece M, which laſt ſuſtains the plates A and C. At one extremity there is a braſs ball D, and the other is prolonged by the addition of a cylinder of ſolid glaſs, which ſuſtains the handle L, and the piece G H, which is ſeparately inſulated. The handle L, beſides the purpoſe of moving the axis, ſerves alſo as a counterpoiſe to the revolving plate, and thereby enables the axis to remain

main at reſt in any poſition. E F are pins riſing from the metal of the fixed plates A and C. The croſs piece G H, and the piece K lie in one plane, and have their ends armed with ſmall pieces of harpſichord wire, in order that they may gently touch the pieces E F in certain points of the revolution. There is a pin I in the piece M, which touches the metal of the revolving plate B. There are likewiſe ſeveral collecting wires twined round the croſs piece G H with their ends ſpread outwards.

The touching wires are ſo adjuſted, by bending, that when the revolving plate B is immediately oppoſite the fixed plate A, the croſs piece G H connects the two fixed plates; at the ſame time that the wire and pin at I form a communication between the revolving plate and the ball D. On the other hand, when the revolving plate is immediately oppoſite the fixed plate C, the ball becomes connected with this laſt plate by the touching of the piece K; the two plates A and B having then no connexion with any part of the inſtrument. In every other poſition the three plates and the ball will be perfectly unconnected with each other.

When the plates A and B are oppoſite each other, the two fixed plates A and C may be conſidered as one continued body, poſſeſſing the ſame electric ſtate; and the revolving plate B, together with the ball D, will conſtitute another continued body, poſſeſſing the contrary electric ſtate. For all the experiments yet made concur to prove that theſe two ſeparate bodies will not poſſeſs the ſame electric ſtate; but that with reſpect to one another their electricities will be poſitive and negative. Therefore the plates will always take the form of a charge, if in their approximation they do not actually touch one another. The rotation, by deſtroying the contacts, preſerves this unequal diſtribution, and carries B from A to C at the ſame time that the wire K connects the ball D with the plate C, the electricity in B will now act upon that in C, and leave it with its firſt electric ſtate augmented; and reſtores B to its firſt ſituation oppoſite A. Here, if we attend to the effect of the whole revolution, we ſhall find that the electric ſtates of the reſpective ſeparate bodies muſt have been greatly increaſed. A ſecond rotation will, of courſe, produce a proportional augmentation of theſe increaſed quantities; and a continuance of the operation will ſoon bring the intenſities to their maximum, which is limited by an exploſion between the plates.

If one of the parts be connected with a ſenſible electrometer, theſe effects will be very clearly ſeen. The ſpark is uſually produced by a number of turns between fifteen and twenty, and the electrometer is ſenſibly electrified by much fewer. When one of the parts is occaſionally connected with the earth, or when the adjuſtment of the plates is altered, there are ſome variations in the effects, not difficult to be reduced to the general principles, but ſufficiently curious to excite the meditations of perſons the moſt experienced in this branch of natural philoſophy. An attention to brevity, however, renders it neceſſary to forbear enlarging upon them *.

Since

---

* Glaſs globes, or cylinders, often meet with accidents. Query, would not a doubler of electricity, properly mounted with large braſs plates,

Since the time in which Mr. Canton made his pith-ball electrometer for exhibiting very ſmall quantities of electricity, the importance of ſuch inſtruments has occurred to many electricians; and many curious and well contrived electrometers bave been made, which by gradually advancing in their ſenſibility, have at length produced that very ingenious and moſt ſenſible inſtrument the Electrical Doubler. This inſtrument ſeems to be the laſt effort of genius; and its electrical powers are truly admirable. But the origin of its remarkable effects has been attributed to ſome ſmall quantity of electricity, generally adhering to its *plates* and other *parts*. To this, however, I could never give my aſſent.

I have therefore been curious enough to ſearch into the laws by which it acts, and the ſource whence its electricity is derived; and the more ſo, becauſe the ſpontaneous electricity of the doubler was deemed a defect, even ſo great, that the inſtrument would be rendered uſeleſs if that could not be removed. For this reaſon I determined to try ſets of plates made of various ſorts of ſubſtance, in hopes of attaining ſome ſubſtance whoſe ſuppoſed adheſive electricity would not influence the proceſs, by the approximation of its parallel plates.

To make this matter eaſy to myſelf, my doubler is ſo contrived that each plate is fixed in its place with one

plates, anſwer all the purpoſes of the moſt powerful electrical machines? I think I can conceive how it may be done. It will no doubt be difficult to make the revolving plate gradually recede proportionally as the charge advances.

ſcrew, by which I can quickly take off a ſet of plates, and eaſily replace others: and to give the plates a conſiderably more extended inſulation than that made by Mr. Nicholſon, without augmenting the ſize of the inſtrument, the fixed plates are elevated above the axis that carries the revolving plate, by bending the glaſſes which ſupport them in the middle to a right angle, which gives the inſtrument, with its *glaſs plates*, the aſpect of a pair of ſpectacles inverted, and which has occaſioned it to be named the *Spectacle Doubler*.

I have carefully repeated many experiments with ſets of plates made of different ſorts of metal, and of wood, horn, leather, gypſum, ſal-ammoniac, ſal-prunella, alum, and glaſs; all of which, upon trial, produced ſpontaneous electricity of the ſame kind, and nearly of equal intenſity, a circumſtantial account of which, for the ſake of conciſeneſs I paſs over, and content myſelf with obſerving, that the ſpontaneous electric charge of the doubler, and that of my high pointed rod, were generally of the ſame kind of electricity within the room in which the lower end of my high rod terminates, though placed at the greateſt poſſible diſtance from each other. But if at any time they varied, it was an eaſy matter to account for it. I therefore conclude, that the rod and doubler acquire their ſpontaneous electricities from one and the ſame common ſource, viz. the electrified vapour ſuſpended in the atmoſphere.

The obſervation that when the doubler was mounted with glaſs plates its effects were preciſely the ſame as when plates of braſs or other ſubſtance were uſed, is very much in favour of the above-mentioned concluſion, which I had drawn from numerous experiments; becauſe ſmooth glaſs by the uſual treatments never produced negative electricity; whereas by the operation of this inſtrument, ſmooth glaſs becomes electrified negatively or poſitively, juſt as the aerial vapour happens to be electrified with either kind.

I have, indeed, two or three times obſerved, that when the electric ſtate of the rod was rather weak, and a change of kind happened in ſuch weak ſtate, the doubler in that caſe would not keep pace with the rod; which at firſt ſurpriſed me very much. But I ſoon conſidered that the rod became charged from electrified vapour without, and the doubler from that within the room, and that the vapour within a cloſe room could not change its electric ſtate ſo quick as that without. I therefore opened the windows, to permit the vapours more freely to mix, which in a few minutes had the expected effect, for on trial the doubler became charged with the ſame kind of electricity with that of the rod itſelf. On the other hand, when the rod is more intenſely electrified, its electric charge will ſometimes induce in the air of a cloſe room a contrary ſtate of electricity to that of its own. In this inſtance alſo the doubler and rod will vary, for their electric charges will not be of the ſame kind, nor ought it ſo to be accordto the concluſion I have made. The doubler thus circumſtanced will become ſtrongly electrified by one revolution only.

There is one very great difficulty attending the uſe of the electrical doubler, and which, doubtleſs, will occaſion many miſtakes, unleſs great care be taken. On this account we have not, as yet, any criterion whereby to know when the doubler is in a neutral or unelectrified ſtate. This difficulty ariſes from the perfection of this inſtrument, by which it is able to be a teſt to all others, but no one can be a teſt for it. It is therefore certain, that communicated electricity muſt be a degree more intenſe than that of the atmoſphere at the time that the experiment is made, otherwiſe the reſults will be equivocal.

When I uſe the doubler of electricity, I am cautious not to carry on the doubling proceſs too high; becauſe I find that a weak charge is more eaſily got rid of than a ſtrong one. If it is only the kind of electricity that one wants a few revolutions will be ſufficient for the purpoſe.

I beg leave, however, here to relate, that in my two years journal on atmoſpherical electricity, which is placed at the end of this work, there is not one obſervation taken by means of the doubler. For although I am ſatisfied that the ſpontaneous electricity of the doubler is as really atmoſpheric as that of my high pointed rod, yet as that matter is not generally admitted, I could not venture to force my opinion upon the public. However, for the ſatisfaction of the curious, I ſhall here inſert an *Electrico-Meteorological Journal*, taken by means of the doubler of electricity, mounted with *glaſs plates*, in three different ſtations, *viz.* Firſt, The doubler was placed on a ſtone pavement, on the north ſide of my houſe; Secondly, on the wood handrail of a bow window, 27 feet high over the pavement; and Thirdly, in the room wherein the lower end of the high rod terminates. The firſt column ſhews the contemporaneous kind of electricity indicated by the high pointed rod. The time of making the obſervations was nine o'clock in the morning.

1790. Nov.	High Rod	Gr.	Bow W.	Roo	Wea.
27.	Poſ.	Neg.	Poſ.	Poſ.	fog
28.	Poſ.	Neg.	Poſ.	Poſ.	foggy
29.	Poſ.	Poſ.	Poſ.	Poſ.	clear
30.	Poſ.	Poſ.	Poſ.	Poſ.	ſnows
De. 1.	Null.	Neg.	Poſ.	Poſ.	fair
2.	Signs	Neg.	Neg.	Neg.	clear
3.	Poſ.	Neg.	Poſ.	Poſ.	fog
4.	Signs	Poſ.	Neg.	Poſ.	clear
5.	Signs	Neg.	Neg.	Poſ.	clear
6.	Null.	Neg.	Neg.	Poſ.	rains
7.	Poſ.	Neg.	Neg.	Poſ.	fair
8.	Null.	Poſ.	Poſ.	Neg.	mild
9.	Signs	Neg.	Neg.	Neg.	mild
10.	Signs	Poſ.	Poſ.	Poſ.	fair
11.	Poſ.	Neg.	Poſ.	Poſ.	fair
Dec.	High Rod	Gr.	Bow W.	Roo.	Wea.
12.	Poſ.	Poſ.	Poſ.	Poſ.	fair
13.	Null.	Poſ.	Poſ.	Poſ.	rains
14.	Signs	Neg.	Poſ.	Poſ.	rains
15.	Null.	Neg.	Neg.	Neg.	rains
16.	Neg.	Neg.	Neg.	Neg.	rains
17.	Null.	Poſ.	Poſ.	Poſ.	foggy
18.	Neg.	Neg.	Neg.	Neg.	gloomy
19.	Signs	Neg.	Neg.	Neg.	rains
20.	Signs	Poſ.	Poſ.	Poſ.	fair
21.	Null.	Poſ.	Poſ.	Poſ.	fair
22.	Null.	Poſ.	Poſ.	Poſ.	fair
23.	Signs	Poſ.	Poſ.	Poſ.	foggy
24.	Neg.	Neg.	Neg.	Neg.	rains
25.	Neg.	Neg.	Neg.	Neg.	fair
26.	Poſ.	Neg.	Poſ.	Poſ.	fog

I ſcarcely need obſerve that this journal of thirty days, only includes that part of each day in which the obſervations were made, and which was generally completed in leſs than half an hour.

The conſtruction of electrometers has been varied according to the purpoſes for which they have been deſigned, and the different degrees of electricity intended to be ſhewn by them. When we are inveſtigating the nature of atmoſpheric electricity we require the moſt ſenſible electrometer poſſible, that it may indicate the leaſt perceptible portion of it exiſting in the humidity of the air.

I have uſed, for this purpoſe, very ſmall ſilver wire, gold leaf, ſilver leaf, fine flaxen threads, &c. To the laſt of which, I now give the preference; becauſe I think they poſſeſs the greateſt ſenſibility, and are leaſt liable to accidents.

The threads are made thus: I take flax as it comes from the heckle, or flax comb, and I firſt ſplit the threads ſo fine that they will almoſt float in air, I then make a loop at one end, and ſuſpend them by it from a metallic hook or ring, after which I dip the point of a ſmall pin in hot glue, and thus join one pin to the lower end of each thread. They, by their weight, will keep the threads ſtraight; and that they may remain ſo, when the pins are cut off, I wet my finger and thumb with glue ſize, and gently preſs the threads between them from top to bottom. When they are dry I carefully remove the pins, and the threads will hang ſufficiently ſtraight. I make them of various lengths, ſome with, others without balls to them; incloſed in glaſs cylinders; for without the glaſs the threads would be ſo agitated by the leaſt motion of the air, that they would be entirely uſeleſs. The threads of my moſt ſenſible electrometer are eleven inches long.

In order to ſucceed well in electrical experiments, much depends on having a good inſulation to our electrometers. I have tried various ſubſtances with a deſign to improve the inſulating power of glaſs, viz. by coating glaſs with hard red ſealing-wax, ſhell lac, copal, amber, &c. But I cannot determine which of theſe ſubſtances (when laid on glaſs) is poſſeſſed of the greateſt inſulating power. But this is evident, that their inſulating quality is conſiderably increaſed by only warming them before the fire. Atmoſpherical electricity is ſometimes ſo circumſtanced, that it would be in vain to attempt to collect it, if the inſtruments were not previouſly warmed.

CHAPTER V.

Containing ſome general Obſervations on Lightning.

IT is ſaid that lightning happens almoſt daily in ſome hot climates; both with and without ſtorms; even in the moſt ſerene weather, if there are any clouds in the atmoſphere, ſufficient to accumulate the matter of lightning. And that the lightning happens more frequently, and in greater quantity, after the ſun has paſt the meridian, than otherwiſe.

Whether we contemplate the matter of lightning as it reſpects atmoſpheric or artificial electricity, the ſubſtance is preciſely the ſame; in both caſes, the fluid is retained, and its effects tranſmitted by the ſame mediums; than which there is not, perhaps, a ſurer criterion to determine the identity of this ſubtile matter.

I conſider lightning to be ſpontaneous electricity in the higheſt degree. I am therefore under a kind of neceſſity in writing this eſſay, to deliver my thoughts on this intricate ſubject. An electrician cannot help forming ſome idea, if not an hypotheſis, how, or in what manner, an event, which indubitably ariſes from an unequal diſtribution of the electric fluid, in the earth and atmoſphere, is produced. Which ſpontaneouſly becomes perhaps the moſt formidable and irreſiſtible agent in the univerſe. Notwithſtanding this, it appears, from various facts and experiments, that the matter of lightning in moderate quantity, is not only perfectly inoffenſive, but abſolutely neceſſary, for the well-being of animals and vegetables, ſuch as is conſtantly found connected with moderate hail, ſnow, rain, fog, and dew.* Which diſtribution of the fluid, may be conſidered as nature equipt in her beſt attire; circulating this wonderful and extremely ſubtile and elaſtic fluid, to the all wiſe beneficial purpoſes, for which it was originally deſigned, by the Author of Nature. But I conſider ſuch a diſpoſition of the elements, as conſtitute thunder-guſts, to be nature in a ſtate of apparent diſorder.

The ſame kind of diſtinction may be applied between moderate wind, and hurricanes of wind; between moderate rain, and inundations.

A ſort of lightning is ſometimes ſeen in this climate in a ſummer's evening, playing among the clouds. This kind of lightning, generally happens in warm ſerene weather, and ſeems quite harmleſs; and is never attended with thunder. Theſe circumſtances plainly ſhow, that ſome cauſe or circumſtance is wanting, to produce miſchievous effects. I conceive that cauſe to conſiſt, chiefly, in the diſtance of the phenomenon from the earth; which is too great for the electrical atmoſpheres of ſuch clouds to diſturb the electricity of the earth. And is probably nothing more than the concourſe of two or more oppoſitely electrified clouds, darting their electrical charges into each other. When I have been able to obſerve the direction of this kind of lightning, it was generally obſerved to be horizontal, or nearly ſo; excepting when it was evidently drawn aſide by the adjacent clouds, which ſeems to indicate that it had but little, if any communication with the earth. Nor have I ever obſerved my high pointed rod, to be more than ordinarily electrified, during ſuch lightning.

---

* See the Journal for July 20, and Nov. 12, 1789.

Before I conſider that ſort of lightning, which often produces dreadful effects, I beg leave firſt, to correct two or three common errors, which ſeem to have ſprung from the prejudice of education in ſome perſons, and from too little attention in others.

Firſt, there is no harm in, conſequently no cauſe of fear, to be apprehended (however ſenſibly it may affect ſome) from the rumbling noiſe of thunder; becauſe it conſiſts only in a ſudden concuſſion of the air, occaſioned by the rapid and violent paſſing of lightning through it. The damage to be apprehended is abſolutely from the lightning itſelf. Therefore thoſe vulgar notions which are ſtill retained by ſome, of *thunder-bolts*, hurling deſtruction whereever they are ſaid to fall, are all deluſive dreams; which ideas, I am of opinion, originally ſprung from *heathen mythology*. Becauſe Jupiter is ſaid to be the god of thunder; and they have deſcribed him as holding thunder-bolts in his right-hand; that is to ſay, ſomething to repreſent fire, flame, and zig-zag lightning.

The ſecond, regards the direction of lightning. It is an idea mentioned in many books, and entertained by almoſt every perſon, with whom I have converſed on this ſubject, that all the lightning we ſee deſcends from the clouds. This ſentiment ſeems to have been the effect of inattention. For when the immenſe quantity of lightning, which is uſually ſeen diſplayed even in common thunder-ſtorms, is ſeriouſly conſidered, I ſhould imagine that it would ſtagger any one to think that the clouds could ever contain it all: and the more ſo, when it is further conſidered, that the earth itſelf is the grand ſource of lightning, and that none can deſcend from the clouds but what firſt aſcended from the earth. Yet the quantity of it which quits the earth in ſettled moderate weather, is ſo remarkably ſmall, as to be juſt ſufficient to determine the aqueous vapours to be electrified poſitively. But that quantity, be it great or ſmall, muſt neceſſarily render the earth in proportion thereto electrical in the oppoſite ſtate. Thus art, is only an happy imitation of nature. By which, we indiſputably know, that when an inſulated body (as is the caſe of a cloud) is rendered electrical in one kind, an uninſulated body near it, will alſo thereby become electrical of the contrary kind.

But

But to what height the daily electricity aſcends into the atmoſphere is quite uncertain. We are ſure that the electric fluid often returns to the earth more copiouſly, concealed in the boſom of *ſnow*, *hail*, and *rain*, which muſt in ſome degree compenſate for the loſs, daily ſuſtained by the earth; and ſo recruits and keeps up the perpetual circulation of this wonderful agent.* Now, ſhould the ſilent, and inviſible deſcent of the electricity, by means of ſeaſonable ſhowers, be equal to the daily aſcent by means of heat and vapour; whence is that amazing continued blaze of lightning, which is uſually obſerved in thunder ſtorms, and which is ſometimes continued during ſome hours?

It is a common notion, and generally adopted in the deſcription of thunder ſtorms, or of the damages occaſioned by lightning, that the matter of lightning always comes from the clouds and goes to the earth. That this is ſometimes the caſe there is no manner of doubt; but I can with confidence aſſert, that the contrary of this propoſition takes place much more frequently, viz. that the matter of lightning, or the electric fluid, proceeds from the earth and goes to the clouds. But this will be diſcuſſed more fully in the two following chapters.

Thirdly, a great variety of terms are commonly uſed in deſcribing the appearances, and effects of lightning, which are very indefinite, and do rather miſlead than inform the reader. Such as flaſh, vivid dart, forked, zig-zag, ball of fire, cable of light, and a ſheet of continued blaze, &c. If a lighted torch be whirled round like a ſling, the rapidity of the motion will exhibit to the eye, a circle of light, or if the torch be ſwiftly moved in a right line, or in zig-zags, the appearance of light will ſeem to follow the ſame direction. Therefore we ought not to ſuppoſe, when we ſee a body of electric light in its paſſage between two conductors, that it does actually fill at the ſame inſtant of time, the whole tract it paſſes through. But theſe, though the beſt arguments which the ſenſes can furniſh, of the courſe of lightning, are but faint repreſentations, when it is conſidered that the velocity of lightning has been found, by experiment, to be nearly inſtantaneous.

---

* I have received the falling rain, hail, and ſnow, into an inſulated veſſel which was ſometimes found to be electrified; eſpecially ſo when my high pointed rod indicated an intenſe electricity in the falling meteors. The manner of doing this may be ſeen in the journal for the 20th of July, 1789.

CHAPTER VI.

Containing Experiments and Obſervations, tending to prove that every Flaſh of Lightning conſiſts of poſitive and negative Light; and which ruſh into Union from two oppoſite Directions.

I Am not certain, that the following ideas, on the two electricities, ever entered into the mind of thoſe electricians who have been ſtrenuous advocates for the doctrine of *two electric fluids*. They ſuppoſed, indeed, that there were two electricities, which had a ſtrong chymical affinity with each other, at the ſame time that the particles of each have a ſtrong repulſion amongſt themſelves; and that theſe two electricities were equally attracted by all bodies exiſting in intimate union in their pores; and while they continued in this union they exhibited no marks of their exiſtence. They alſo obſerved, that every electric ſpark conſiſts of both electricities ruſhing contrary ways, and making a double current. But this doctrine ſeems now to be intirely ſupplanted by the more natural theory, of *one electric fluid*; which is ſimple and eaſily conceived, and every way ſufficient to explain effects and appearances. To which I ſubſcribe, and from which I have not intentionally deviated throughout this narrative.

The greateſt difficulty attending the contemplation of the phenomenon of lightning, is the vaſt quantity of the matter of lightning, which uſually appears during great thunder ſtorms. The perplexity attending the conſideration of this fact, will (I preſume) be conſiderably diminiſhed, if the reſults of the following experiments, and the reaſoning and application I have made of them, are well founded.

I conceive that this globe of earth and water, with its plants, animals, and buildings, have diffuſed throughout their ſubſtance a certain quantity of the electric fluid, which is termed their natural quantity: and while this equable diſtribution continues undiſturbed, their electricity is in all reſpects inviſible. But if the balance of this diffuſion, be by any means deſtroyed, either in the earth or atmoſphere, then it becomes viſible in proportion to that diſturbance. Hence the terms poſitive and negative, denſity and rarity, redundancy and deficiency, &c. are only applicable to the electric fluid during its diſturbed ſtate.

This being premiſed, we will now ſuppoſe a thunder cloud coming already highly charged with the electric fluid, which cloud, in its paſſage through the atmoſphere, ſeems to hover over a high tree. The tree, and the earth to a limited diſtance around it, will become thereby electrified; but of an oppoſite kind of electricity to that in the cloud.* The electricities of the earth and cloud, being thus circumſtanced, and their atmoſpheres approaching nearer and nearer, muſt neceſſarily act with very great attractive force on each other. One body being highly poſitive, and the other of courſe as highly negative, will urge their way with great violence through the reſiſting air, which intervenes between them. Now ſhould the atmoſpheric conducting matter, which lies between the two powers, be equally diſpoſed and in ſome ſmall degree able to conduct the electricity of the earth above the tree, the exploſive flaſh of lightning, will take place in the air, over the tree, at the ſtriking diſtance between the two powers; and at the ſame time reſtore the equilibrium of the electric fluid, to the earth and cloud.

Now any perſon, perceiving the flaſh of lightning, and judging by the appearance, would no doubt readily conclude,

---

* It is dangerous, therefore, to take ſhelter under a tree during a thunder ſtorm. It has been fatal to many, both men and beaſts. It is ſafer to be in the open field, becauſe wet clothes tend to prevent harm from a flaſh of lightning.

clude, that it all iſſued from that black cloud; whereas one half of ſuch flaſh of lightning, muſt immediately aſcend out of the earth, and the other deſcend from the cloud.

If the intervening air which lies between the two powers, ſhould happen to be dry, and therefore not able to elevate the electricity of the earth above the tree, the exploſion muſt in this caſe, take place in or near the tree, which it is very probable, would be ſhattered to pieces, by the force or impetuoſity, whereby the two electricities unite. But in the former caſe, the tree might ſuſtain no injury. The ſame reaſoning will hold good if the maſt of a ſhip, or lofty building, were to be a part of the conducting medium between the two electricities.

That the main force of lightning, muſt happen nearly in the middle of all reſiſting mediums, which lie between the two electricities; and that when the exploſion takes place, the light ſeen is made up of poſitive and negative, in one appearance of light, as above aſſerted, I ſhall endeavour to illuſtrate and confirm, by ſelecting a few experiments and obſervations.

The reader will eaſily perceive, that I conſider the ſtate of the electric fluid, during a thunder ſtorm, to be ſituated in the earth and atmoſphere, ſimilar to the experiment of a charged Leyden bottle. I perceive no material difference between them, but what relates to quantity, except this; and without this, I ſee not how the phenomenon of lightning could ever happen in nature. It is this: the electric charge of the Leyden bottle principally adheres to the ſurface of the glaſs, and not to its coating; but when a plate of air is ſaid to be electrified, the charge always adheres to the coating; that is to ſay, to the clouds or aqueous vapours ſuſpended in it. This nice diſtinction (which nature obliges the philoſopher to notice) does not ariſe from the great thickneſs or quantity of air, which, in thunder ſtorms, may occaſionally happen to be between the electrified portion of earth and clouds; but it ariſes from the reſiſtance of air to the electric fluid. I find by the operation of the electrical doubler, that the Leyden experiment is perfectly formed, though the portion of *air* between the two fixed plates, and revolving plate, be only one fiftieth part of an inch.

With regard to air itſelf (which ſeems to be the moſt perfect non-conductor of electricity) when ſimply conſidered, it ſeems to be originally void of electricity (which is common to all other matter), and that air, as air, is actually incapable of abſorbing or retaining it, but in proportion to the foreign matter mixt with it. And that the permeability of air to the electric fluid, is owing to its fluidity and extreme elaſticity, which cauſes it to yield to the leaſt partial preſſure. It was neceſſary that air ſhould poſſeſs theſe properties, in order that the two electricities might manifeſt themſelves by thoſe appearances which we term lightning. Conſequently, during a thunder ſtorm, the earth and clouds operate as coatings to the plate of air that lies between them. That this is a real fact, there ſeems no room for doubt, after that deciſive experiment of charging a plate of air, ſo as to give a ſhock like that of the Leyden bottle.

EXPERIMENT I.

The electric charge of the Leyden bottle is limited by the compact texture and thickneſs of the glaſs; for if the charge be urged too high, the electricities will force a hole through it, and the tinfoil coating will be rent up in a bur, on both ſides of the glaſs; and will ſometimes be melted. Which ſhows plainly, that where the poſitive and negative electricities re-unite, there the greateſt effort is exerted. In this experiment, the two electricities ſeem to meet in the middle of the thickneſs of the glaſs. Which is ſtrongly indicated by the *bur* being protruded from the middle of the glaſs. Similar effects will take place, if the circuit be interrupted by ſeveral folds of paper, for a hole will be made through them, and each leaf will be protruded by the two electricities, from the *middle* towards the outward leaves.

EXPERIMENT II.

With a jar highly charged, containing nearly ſix ſquare feet of coated glaſs, I have melted ſmall iron wire into globules of metal. This fine experiment is attended with ſome difficulty, for if the charge of the jar ſhould happen to be too ſtrong, the wire will be diſperſed; if too weak, it will only be made red-hot. But ſometimes the electric charge will be of a proper intenſity to melt the wire into fine globules. When this ſurpriſing effect happens, I have often obſerved the wire to be of a more pale red heat in the *middle* than at its extremities, and the melting of it to begin *there*; leaving a part at each end unmelted. At other times (though leſs frequent) the wire was obſerved to be of a more glowing heat in two parts of it, than in the reſt, which generally happened to be a little above and below the middle of it. Theſe effects clearly ſhow that the poſitive and negative electricities of the charged jar muſt have met in great force near the middle of the wire, where the reſiſtance to their union was greateſt.

EXPERIMENT III.—*By Lightning.*

Dr. Franklin, in his account of the effects of lightning, on the church of Newbury, in New England, obſerves "that a wire, not bigger than a common knitting needle, did in fact conduct a flaſh of lightning, without injuring any part of the building as far as it went; though the force of it was ſo great that, from the termination of the wire down to the ground, the ſteeple was exceedingly rent and damaged; ſome of the ſtones, even in the foundation, being torn out, and thrown to the diſtance of twenty feet. No part of the wire, however, could be found, except about two inches at each extremity, the reſt being exploded."

From the circumſtance of two inches of the wire being found to remain intire, at each extremity, I infer, that the poſitive and negative electricities muſt have met at about midway between the two extremities, and there the reſtoration of the electrical equilibrium, muſt have taken place between the earth and cloud. If the wire had been extended to the earth, poſſibly no damage might have happened to the building. Theſe inferences ſeem to be juſt, from the circumſtances of the caſe; and are alſo confirmed by the well known effects of large electrical batteries; for when the charge of a battery is made to paſs through, or meet in a very ſmall wire, which on account of its ſmallneſs muſt occaſion ſome reſiſtance to the re-union of the two powers, yet in all caſes, whether the wire be melted or exploded, the electrical equilibrium of the battery is always, without exception, found reſtored by the exploſion.

We will now take a view of this matter, as it appears in the electrical ſpark, which, I am perſuaded, when carefully examined, will be found to conſiſt of both electricities, ſtretching or extending themſelves beyond the conducting ſurface, in order to leſſen the leap through the reſiſting medium of air to their union. For every moment during their diſunion they are conſtantly endeavouring to unite, (which endeavour, or mode of action, is uniform and reciprocal,) and preſs into, or attract each other, like the north and ſouth poles of two magnets*.

EXPERIMENT IV.

My electrical machine has two prime conductors, made of copper, each containing about 300 ſquare inches of ſurface, both well inſulated. This machine, when placed on the ground, having a braſs ball of two inches and a half diameter, ſuſpended from each conductor, by bent braſs rods, ſo that the balls approach within one inch of the ſurface of the earth; the apparatus being thus diſpoſed, and motion given to the glaſs cylinder, it is beautiful to obſerve how exactly the two electricities ſtrike at the ſame inſtant of time. The negative ſpark iſſues immediately out of the earth, and the poſitive ſpark ſtrikes into it, and thereby reſtores the equilibrium of the electric fluid to the earth, which had been diſturbed by the action of the machine.

---

* The law of electrical attraction ſeems not yet aſcertained, nevertheleſs, it is ſufficiently evident, that equal quantities of both electricities, ſeparately inſulated, act with equal force upon each other; and that their force increaſes as they approach to, and decreaſes as they recede from, one another; but it is not yet known whether this attraction follows any regular proportion.

EXPERIMENT V.

The ſame apparatus affords another very fine experiment, by only elevating the metallic balls and curved rods, ſo as to form an arch over the glaſs cylinder; but as the two electricities, in this experiment, inſtantly dart into each other in air, the braſs balls need not be placed nearer to one another than three or four inches, for on every revolution of the glaſs cylinder a denſe ſpark will explode between them; it is even ſo ſtrong, that if it be taken properly, it gives the Leyden ſenſation. This ſpark may be conſidered as a kind of ocular demonſtration, that when poſitive and negative electricity are accumulated in, and made to meet in air, their light and force ſeem to be apparently doubled. If a curious obſerver examines this light in the dark, he may diſtinctly perceive the uſual *ſigns* of *both electricities* within the reſiſting medium of air, and alſo where they unite, for their place of re-union is noticeable by being much leſs luminous, which is the natural effect of union; for there, in that particular part of the ſpark, the two electricities become again one; there the terms poſitive and negative ceaſe, and there the electric light vaniſhes.

We know that the electricity is in matter, but its properties in that ſtate of union, are, I think, altogether unknown. It has been, however, improperly ſaid, that the poſitive and negative electricities deſtroy one another, becauſe, when united, their viſible effects ceaſe. It is not, therefore, the *cauſe* determining thoſe effects, that is expreſſed by the word deſtroyed, but the *effect itſelf.*

I beg leave, moreover, to remark, that this experiment affords a ſtriking inſtance of the vaſt quantity of electricity that is naturally contained in the pores of metal; for, in the fourth experiment, the ſupply of electricity was immediately from the earth, but in this the ſupply is wholly from the *inſulated metallic conductors.*

EXPERIMENT VI.

This experiment was made by Mr. Nicholſon, with a more powerful electrical machine than mine. A delineation of his ſeven electric ſparks is given in the Philoſoph. Tranſ. vol. 79. Spark third. "When the one ball was electrified *plus*, and the other *minus*, the ſigns of both electricities appeared. If the interval was not too great, the long zig-zag ſpark of the *plus* ball ſtruck to the ſtrait flame of the *minus* ball, uſually at the diſtance of about *one-third* of the length of the latter from its point, rendering the other two-thirds very bright."

This is an undoubted fact with me, though noticed by very few electricians. Mr. Nicholſon's deſcription of this ſpark evidently exhibits, in one point of view, the poſitive and negative electricities, uniting in air, and ruſhing into each other in oppoſite directions. I think, however, that Mr. Nicholſon, in his narrative, ſeems to be a little embarraſſed with the old doctrine on this ſubject, which, indeed, ſhould never be invaded on ſlight evidence; I admire his tenderneſs in this reſpect; but why the luminous appearances in his fig. 6, ſhould differ ſo widely from thoſe of fig. 3, is to me unaccountable, for the uſual ſigns of both electricities are plainly obſerved in all his experiments, and delineated in fig. 1, 2, 4, 5, 6, and 7, though not quite ſo conſpicuous as thoſe of fig. 3.

It is well known to electricians that the appearance of electric ſparks, taken in air, is ſubject to many variations, which are occaſioned by the change even of the moſt trifling circumſtance; yet there are certain criterions peculiar to each kind of electricity, which evidently ſhow that every ſpark muſt conſiſt of both electricities, one end of which always exhibits the poſitive, and the other the negative ſigns. For inſtance, if the negative part of a ſpark be ſmall, or what has been uſually termed a luminous globule, then the middle part of it is generally of a purpliſh colour. When ramified rays iſſue from the poſitive part, then the negative part is more extended, ſtretching out towards the poſitive; and when the poſitive and negative parts ſtrike into each other in denſe light in various parts of the intermediate ſpace, then their exact place of union is generally obſervable by a dark ſpot. Hence I infer, as before obſerved, the loſs of light, whether total or partial, that may happen in any part of an electric ſpark, to be the immediate effect, and conſtant ſign, of the re-union of the two electricities. It is further to be obſerved, that whether the negative light aſſumes the figure of an oblong flame, or of a luminous globule, in either caſe the poſitive light is ſeen to approach and unite with it, in all poſſible directions. I find, as Mr. Nicholſon has determined, "that the effect of a poſitive ſurface appears to extend farther than that of a negative."

As the middle part of an electric ſpark often appears of a dilute purpliſh colour, and its ends more vivid and white, it has been conjectured by ſome to ariſe probably from the fluid meeting with the greateſt reſiſtance at its entrance and exit. I imagine, however, that this idea was ſuggeſted (for I know of no fact in the ſcience of electricity itſelf to prove it) by the reſiſtance and refraction which the rays of light ſuffer in paſſing from one ſubſtance into another. But it will appear with the leaſt conſideration, that there is a very great difference between the light of the ſun and that of electricity; I therefore conclude from the foregoing experiments, that all electrical exploſions conſiſt of both electricities ruſhing into union from oppoſite directions.

We ſhall now proceed to examine the appearances of the two kinds of electricity which take place in vacuo.

I think it was in the year 1776 that I was employed by John Walſh, Eſq. F. R. S. to procure ſome double barometer glaſs tubes, or long bent tubes of glaſs, and to aſſiſt Mr. De Luc to boil carefully the mercury within them, in order to obtain a perfect vacuum in the arch above the mercury. One of them being completed, trial was made to paſs the electric charge of the Leyden bottle through the vacuum, but it could not be done; nor was there any luminous appearance perceived in this barometer. Perhaps the electric fluid is not capable, by its own expanſive power, of extending itſelf into ſpaces void of all matter.

I mounted a glaſs tube three feet ſeven inches long, of about one inch bore, with braſs caps; one of the caps was fitted to the plate of an air-pump; a braſs wire and ball extended a little farther within the tube than the caps did on the outſide of it. This tube was ſcrewed to the plate of an air-pump; but while the air within it remained of its natural denſity, the charge of the Leyden bottle could not be tranſmitted through it, any more than through a perfect vacuum. But if the air-pump was worked for a ſhort time, ſo that the air within the glaſs tube might be conſiderably rarefied, then the charge of the Leyden bottle would eaſily paſs through the rarefied air, and fill the whole capacity of the tube with electric light.

EXPERIMENT VII.

That to which I would wiſh the philoſopher to attend chiefly in this experiment, is the direction and appearance of the two electricities within the glaſs tube, which is beſt done when the electric charge of the Leyden bottle is rather too weak to force its whole contents ſwiftly through the rarefied air, for, otherwiſe, the motion of the fluid is ſo rapid, and its light ſo reſplendent, that the eye cannot diſtinctly notice its operations. When you examine the appearances in the dark, at the moment the circuit is formed to paſs the charge, you will diſcover ſome light within the tube, chiefly at each end of it. Theſe lights are of contrary kinds of electricity, and agree with the charged ſide of the bottle, to which they are connected by metal. It may ſometimes be clearly perceived, when the charge is of a proper intenſity, that the two lights have a manifeſt tendency to meet near the middle of the reſiſting medium, (provided that the glaſs tube be perfectly clean and dry) and thereby reſtore the equilibrium to the ſides of the bottle; but, in this caſe, the equilibrium is but partially reſtored, becauſe the two powers do not unite in ſufficient quantity to effect it.

I have frequently obſerved the light within the exhauſted tube to be conſiderably diminiſhed in its ſplendour where the two powers unite; and in air alſo, as we mentioned before, a dark ſpot is obſervable near the middle of many electrical ſparks. Theſe appearances are the conſequence of union, and ought to be ſo, becauſe in proportion as the two electricities unite, and regain their natural ſtate, they loſe their light; for the electrical ſubſtance is only luminous in a divided ſtate, whether it be viewed in vacuo or in air.

That theſe two remarkably diſtinct powers ſhould tend to re-unite near the middle of all reſiſting mediums is natural, becauſe there the two electricities meet with a greater reſiſtance than in any other part of the circuit, conſequently there their whole force will be exerted to overcome the reſiſtance, and, of courſe, will there become moſt conſpicuous in their effects.

EXPERIMENT VIII.

Similar effects and appearances are obſerved, and eaſier performed, if the air-pump and glaſs tube ſcrewed to it be placed ſo that an half-inch ſpark from the prime conductor of an electrical machine be made to ſtrike the upper cap of the glaſs tube: and here alſo, in this mode of performing this experiment, the light ſeen within the tube conſiſts of contrary kinds of electricity; for, if the electric ſpark communicated to the upper cap of the glaſs tube be of the negative kind, the cap and light within near to it will be negative alſo, and the light within the tube at the lower end will be of the poſitive kind; and alſo the air-pump, and the table it ſtands upon, though uninſulated, will give ſufficient proof, if examined by a ſenſible electrometer, of their being electrified poſitively.

There is another important appearance, which has been entirely overlooked, and which (I think) is not the leaſt, to illuſtrate and confirm the principles here advanced, which will appear in the moſt conſpicuous point of view if the glaſs tube be placed in the following poſition.

EXPERIMENT IX.

Let the exhauſted tube be ſuſpended to the ceiling, parallel to the horizon, by a ſilken ſtring at each end of it. One end of the tube is to be placed ſo as to receive an electric ſpark from the prime conductor of the electrical

machine;

machine; at the other end, a metallic communication with the earth is to approach within half an inch of the metallic cap of the tube. Things being thus adjuſted, and motion given to the glaſs cylinder, it is well known that the glaſs tube will be filled with electric light ſo long as the ſupply of electricity, by the action of the electrical machine, is continued.

Now I am certain, that it is not ſo well known that at the inſtant of time the ſupply ceaſes the light divides near the middle of the tube, and flies back to both ends of it; for, as before obſerved, the light within the tube is not all of one kind of electricity; it includes both electricities in one appearance of light, and the moment the ſupply ſtops their progreſſive motion ceaſes; therefore they are not able to unite within the tube, and of courſe they go out of the tube the ſame way they went into it; one moiety returns to the prime conductor, and the other to the earth from whence it came.

I know, that electricians in general ſay, that air rarefied in a glaſs tube, to a certain degree, permits the electric fluid to paſs eaſily through it. If this philoſophy were true, it would follow, that the ſame kind of electricity which entered the tube at one end, muſt be the ſame all the way through, and ſo come out at the other end of it. But it is not ſo; that is to ſay, that the electric light, within this exhauſted tube conſiſts of poſitive and negative light*. If the operation be continued ever ſo long, and even with a very great force, the fact ſtill remains the ſame; for although a part of its electricity be drawn out by the action of the machine at one end of it, yet, enough always remains viſibly active to meet a quantity of the poſitive kind, which, in this caſe, will viſibly riſe out of the earth and enter the tube at the other end; and ſo both electricities will again unite in it where their diſunion firſt began; hence it is, that this kind of exhauſted tubes never take the form of a charge with any conſiderable force.

---

* It appears neceſſary here to obſerve, that the electrical effects of an exhauſted glaſs tube, having a metallic cap at one end of it, and the

EXPERIMENT X.

To aſcertain this matter beyond diſpute, *viz.* that the light within this kind of exhauſted tubes conſiſts of poſitive and negative light, notwithſtanding it appears to the eye, by its rapid motion, to be but one uniform light, let the glaſs tube remain ſuſpended, as in the preceding experiment, and place a Leyden bottle on glaſs ſtands, at each end, in an horizontal poſition, and in a right line with the tube itſelf, (which will lengthen the apparatus without altering the reſults) with their metallic knobs nearly in contact with the metallic caps of the glaſs tube. In this diſpoſition of the apparatus the coating of one bottle is to receive a ſpark from the prime conductor, and the coating of the other a ſpark from metal, which, for this purpoſe, muſt communicate with the earth. Turn the glaſs cylin-

---

the other end hermetically ſealed, differ conſiderably from thoſe of the tube deſcribed above. The electricity, in this ſort of tubes, acts forcibly on the internal and external ſurface of the glaſs, and will take the form of a charge, even ſo powerfully as to explode and perforate a hole through it, which ſhows its electrical ſtate to be that of a highly charged Leyden bottle.

der

der and ſparks will be perceived to paſs in the four intervals of air, and, at the ſame time, a luminous appearance within the glaſs tube. Remove the bottles, and examine their electric charges, and they will be found to correſpond with the lights within the tube to which they were oppoſed. One bottle will be found electrified poſitively, and the other negatively.

I am of opinion, that if a curious obſerver were to examine this luminous appearance in a dark room, he would ſoon think with me, that he diſtinctly perceived the light divide (whenever the ſupply of electricity ceaſes) near the middle of the tube, and recede to its extremities. I imagine, however, that its rapid motion would not admit of diſtinction were it not for ſomething peculiar to the inſide ſurface of the glaſs tube, which may in ſome ſmall degree retard the electric light in its retreat.

Perſons who are not thoroughly verſed in this branch of philoſophy may ſuppoſe that the ſeveral facts exhibited in the *ten* preceding experiments are only of ſmall conſequence. However ſome may think of, or diſregard them, with reſpect to myſelf, I am fully perſuaded, that the whole phenomena of lightning, as well as many phenomena of artificial electricity, do entirely depend upon them. Many of theſe experiments have been long known, although their effects and appearances, as here remarked and applied, have the effect of novelty. Many books have been written upon this branch of natural philoſophy, but none of them have yet fallen into my hands in which even the leaſt hint of applying theſe experiments, in order to explain the phenomenon of lightning, has been attempted.—It does not appear to have been at all the object of the writers. Some electricians have, indeed, been curious enough to attend to the *direction* of electric light—I wiſh this obſcure particular were better known.

I conceive that though the joining of the two electricities in our experiments is but faintly perceived, yet the fact itſelf promiſes ſome elucidation of the grand difficulty reſpecting the vaſt quantity of electricity obſerved during thunder ſtorms; and the more immediate advantage of this diſcovery is, that it ſuggeſts the idea of a more eaſy ſolution of the phenomenon of lightning than has yet come to my knowledge, and it evidently deſerves the moſt minute examination.

Laſtly, theſe inſtructive experiments on electric light have not yet, perhaps, been explained to the ſatisfaction of the philoſopher; be that as it may, if the uſe and remarks I have here made upon them ſhould happen to be well founded, *viz.* that every flaſh of lighting conſiſts of poſitive and negative light, (not wholly of one of theſe kinds, as has been ſuppoſed) in one apparent flaſh, then will that general *amazement*, reſpecting the immenſe quantity of the matter of lightning, that is uſually diſplayed in thunder-ſtorms *be abated*, by conceiving that the earth does actually ſupply *one* moiety of every flaſh of lightning at the moment that the clouds and vapours ſupply the *other*; but becauſe of their rapid motion through the air they cannot be diſtinguiſhed by the eye as here deſcribed.

CHAPTER VII.

Further Obſervations and Conjectures on the Phenomena of Lightning.

IT is not my intention, in this chapter, to deſcribe the dreadful effects of lightning which happen in violent thunder ſtorms; but what I wiſh to add on this head are chiefly opinions and conjectures, ſtill further concerning the amazing great quantity of lightning obſerved in thunder ſtorms, becauſe it ſeems difficult to conceive how nature effects it.

However, I am perfectly ſatisfied of the truth of what I have here already advanced on this ſubject (ſo far as it extends) concerning lightning obſerved in the atmoſphere, conſiſting of poſitive and negative light in one appearance; and that the light or flaſh happens at the moment of re-union of the two powers, which approach one another with an unparalleled velocity, the force of which is derived from the mutual attraction of each power, that ariſes from the denſity of one and rarity of the other, and is always in proportion to the quantity of electricity that has been diſplaced in a limited diſtrict of the earth and atmoſphere; which ideas of the ſubject, I conceive, muſt leſſen conſiderably the grand difficulty relative to the quantity of electricity obſerved in thunder ſtorms; it is, therefore, very probable that they have erred, who have ſuppoſed that all, or every part of lightning, is of one kind of electricity, and that it all iſſued from a cloud or clouds.

Yet, when I conſider the account given from the North part of France, and from all the South of England, of a tremendous thunder ſtorm, which happened early in the morning of the 23d of December, 1790, it ſhould ſeem that there is ſtill great ſcope for further inveſtigation. I am of opinion, that the immenſe quantity of lightning obſerved during that ſtorm, cannot be accumulated by ordinary or ſimple cauſes. On the contrary, the numerous vivid exploſions of lightning which ſucceeded one another ſo rapidly, and nearly at one and the ſame inſtant, rather lead us to imagine, that a great part of the horizon and atmoſphere are, during ſuch ſtorms, in a ſtate or condition capable of charging and diſcharging themſelves very quick; and that the powers of nature are actually ſo diſpoſed, in the earth and atmoſphere, as to cauſe the electricity to aſcend out of the earth, in a luminous body or flaſhes of lightning, ſucceeding each other very rapidly. But how ſo great and extenſive a redundancy of electricity in one, and deficiency of it in the other, is effected, is hard to determine; yet it is eaſily perceived how nature operates to produce the ſame effects in a leſs degree, which has been already (I preſume) clearly manifeſted in the preceding chapter.

Dr. Franklin, long ago, juſtly obſerved, " that whether the direction of lightning aſcend or deſcend, thoſe who are verſed in electric experiments will eaſily conceive that the effects and appearances muſt be nearly the ſame in either caſe; the ſame exploſion and the ſame flaſh between one cloud and another, and between the earth and clouds, the ſame rending of trees and walls which the electric fluid meets with in its paſſage, and the ſame fatal ſhock to animal bodies."

The cauſe of the tides is the ſtrong attractive power of the moon, and weaker influence of the ſun, which attract all the water in the neareſt hemiſphere, cauſing the waters of the ſea to ſtand higher in one part than in another. This wonder of nature, I conceive, is not altogether void of analogy with that natural phenomenon of electrified clouds, forcibly acting on the electricity of the earth. For, although the electric fluid be too ſubtile to ſtand on an heap like water, yet, when the electricity of the earth becomes redundant (or the contrary) on any part of it, the cauſe of that redundancy is not in the earth, but like that of the tide, is at a great height above it, in the atmoſphere, and the efficient cauſe of both is attraction.

The earth is the grand reſervoir of the matter of lightning, and may poſſibly, in a limited diſtrict, become overcharged, ſo as to throw off flaſhes of light like an overcharged electrical apparatus. I have abundant proof, that a limited part of the earth is ſometimes in an electrified ſtate, becauſe the uninſulated part of my atmoſpheric apparatus is frequently electrified, but moſt ſo during a thunder ſtorm. I therefore infer, that when that part of the apparatus is electrified negatively, the fluid is aſcending out of the earth into the atmoſphere, the former having leſs than its natural quantity in my neighbourhood; and when the ſame part of the apparatus is electrified poſitively, the fluid of courſe is deſcending into it, conſequently a limited part of the earth may be highly electrified; yet, its being inſenſible to us, who even may be on the electrified part, is no proof of its non-exiſtence, ſince we ourſelves are involved in it; for where all things are equally involved in an electrical atmoſphere there can be no viſible ſigns of the preſence of the electric fluid. For the ſame reaſon, if two or more perſons be electrified, ſtanding upon the ſame *inſulation*, they ſhow no ſigns to each other of being electrified, be the quantity of fluid they are involved in ever ſo great. The ſame fact is obſerved to take place in perſons, and things, *uninſulated*, and will be particularly noticed by and by, with the manner of aſcertaining it.

I beg leave here to obſerve, that however ſurprizing it may appear to ſome electricians, who perhaps have had no experience of an atmoſpheric apparatus, that a metallic rod, which terminates deep in the earth, and its upper end nailed to a brick wall to give it ſupport, ſhould, ſo circumſtanced, exhibit ſigns of an electrical charge, would be nothing wonderful, were it poſſible for us to conceive what a vaſt quantity of the fluid is at thoſe times in motion in the earth; and that, whenever the phenomenon happens on any part of the earth, there is always over that part of it, concealed in the clouds and vapours, a proportional quantity of the electricity, but of an oppoſite kind to that on the earth; for, indeed, one electric charge cannot exiſt without the other.

I have been of opinion, that as the brick wall is a leſs conductor of electricity than metal or moiſt earth, it may on that account contribute, in ſome ſmall degree, to the production of the phenomenon, but in this opinion I may be wrong.

Hiſtory informs us, that large quantities of lightning have been ſeen to run along the ground, break into ſeveral parts, and produce ſeveral exploſions at the ſame time; which clearly indicate that a part of the earth may be ſo circumſtanced, that it does not always quickly drink it in. Now, if a limited diſtrict of the earth, where ſuch facts happen, were not previouſly ſurcharged with the ſame kind of electricity with that ſeen diffuſed upon it, how could ſuch a phenomenon take place?

One of the beſt authenticated accounts of lightning ſpreading itſelf upon the ſurface of the earth is that in Dr. Prieſtley's excellent Hiſtory of Electricity, page 400, which I will here tranſcribe.

" But the moſt complete demonſtration of the real uſe of Dr. Franklin's method of ſecuring buildings from the effects of lightning, is Mr. Kinnerſley's account of what happened to the houſe of Mr. Weſt, a merchant of Philadelphia, in Pennſylvania, which was guarded by an apparatus conſtructed according to the directions of Dr. Franklin. It conſiſted of an iron rod, which extended about nine feet and a half above a ſtack of chimnies, to which it was fixed. It was more than half an inch in diameter in the thickeſt part, and went tapering to the upper end, in which there was an hole that received a braſs wire about three lines thick and ten inches long, terminating in a very acute point. The lower part of the apparatus joined to an iron ſtake, driven four or five feet into the ground.

" Mr. Weſt judging, by the dreadful flaſh of lightning and inſtant crack of thunder, that the conductor had been ſtruck, got it examined; when it appeared that the top of the pointed rod was melted, and the ſmall braſs wire reduced to ſeven inches and a half in length, with its top very blunt. The ſlendereſt part of the wire he ſuſpected had been diſſipated in ſmoke; but ſome of it, where the wire was a little thicker, being only melted by the lightning, ſunk down (while in a fluid ſtate) and formed a rough irregular cap, lower on one ſide than on the other, round the upper end of what remained, and became intimately united with it. It is remarkable, that, notwithſtanding the iron ſtake, in which the apparatus terminated, was driven four or five feet into the ground, yet the *earth* did not conduct the lightning ſo *faſt*, but that, in thunder ſtorms, the lightning would be *ſeen diffuſed* near the ſtake two or three *yards* over the *pavement*, though at that time very *wet* with rain."

Theſe effects plainly ſhow that the earth does not always with equal eaſe abſorb the electric fluid. Which I judge, as before ſaid, muſt ariſe from its electrical ſtate peculiar to a limited diſtrict where ſuch extraordinary phenomena happen; for the earth is always moiſt. But to add to that, in the above caſe it is ſaid that the pavement was very wet with rain. This conjecture of mine may at firſt ſight, I own, ſeem improbable; but the great quantity of electricity obſerved in ſuch circumſtances, muſt have an adequate cauſe, and I know of no other cauſe capable of producing that effect.

In the ſame Hiſtory of Electricity, page 394, I find that Pliny, in his ſecond book of Natural Hiſtory, mentioned ſome luminous appearances, and tells us, that they ſettled not only upon the maſts and other parts of the ſhips, but alſo upon men's *heads*, and on the *ſpears* of the ſoldiers who kept watch by night upon the ramparts. Seneca in his natural queſtions takes notice of the ſame phenomenon. A ſtar ſettled on the *lance* of Gylippus, as he was ſailing to Syracuſe: and *ſpears* have ſeemed to be on *fire* in the Roman camp. In the month of February, about the ſecond watch of the night, there was a very extraordinary appearance in the army of Cæſar. There ſuddenly aroſe a thick cloud, followed by a ſhower of hail ſtones; and the ſame night the *points* of the *ſpears* belonging to the fifth legion ſeemed to take *fire*. Livy, chap. 32. mentions two ſimilar facts. It does not appear that the ancients had any proper ideas of theſe facts and appearances; for if they ſaw only one light it was termed Helen, an ill omen; but if two lights appeared they were called Caſtor and Pollux, and were invoked as gods.

It is now evident that theſe luminous appearances muſt have been natural or ſpontaneous electricity. And that a limited part of the earth and atmoſphere muſt when and where thoſe phenomena happened be highly electrical; and alſo every ſubſtance within the electrified diſtrict. For thoſe facts all happened without inſulation, and were ſimilar in that reſpect to the facts obſerved with my *uninſulated* metallic rod. A ſimilar event happened to Mr. Loammi Baldwin (related in the Phil. Tranſ. vol. 72) who raiſed an electrical kite in July 1771, during the approach of a ſevere thunder ſtorm, and obſerved *himſelf* to be ſurrounded by a rare medium of *fire*, which, as the cloud roſe nearer the zenith, and the kite roſe higher, continued to extend itſelf with ſome gentle faint *flaſhes*. Mr. Baldwin felt no other effect than a general weakneſs in his joints and limbs, and a kind of liſtleſs feeling; all which he obſerves might poſſibly be the effect of ſurpriſe, though it was ſufficient to diſcourage him from perſiſting in any farther attempt at that time. He therefore drew in his kite, and retired to a ſhop till the ſtorm was over, and then went to his houſe, where he found his parents and friends much more ſurpriſed than he himſelf had been; who, after expreſſing their aſtoniſhment, informed him, that he appeared to them (during the time he was raiſing the kite) to be in the midſt of a large bright *flame of fire*, attended with *flaſhings*; and that they expected every moment to ſee him fall a ſacrifice to the *flame*. The ſame was obſerved by ſome of his neighbours, who lived near the place where he ſtood.

I conſider this event as the moſt extraordinary inſtance of the kind (where no injury was ſuſtained) that I have yet been acquainted with. That a man ſhould be ſo powerfully electrified, ſtanding on the *ground*, as to be viſibly ſo to himſelf, and alſo to his friends at a conſiderable diſtance from him, and in day-light too, ſhews the immenſe quantity of electricity that he muſt be involved in; and his ſafe eſcape from danger to be little leſs than a miracle. Every one muſt be ſatisfied (who reads this aſtoniſhing account) that Mr. Baldwin was permanently electrified, though uninſulated. It alſo ſeems evident that the part of the earth whereon he ſtood, and that adjoining to it within a certain diſtance, muſt have been in the ſame electrical ſtate. The principal difficulty that will here ariſe with many, will be the apparent want of inſulation to Mr. Baldwin*. But when that is accurately conſidered, it will be found, that the ſurrounding air performed that office by inſulating two highly electrified bodies, viz. the clouds above, and the ſurface of the earth beneath him, which have in ſuch inſtances the effect of coatings to a plate of air, ſimilar to the coatings of a plate of glaſs. Now it is well known, that the Leyden bottle retains its electric charge though one of its charged coatings be uninſulated, or connected with the ground.

It is in my power to ſatisfy any one during a thunder ſtorm, and ſometimes even during the paſſing of a black cloud over my high pointed rod, that the earth is to ſome limited diſtance in my neighbourhood, ſometimes in a redundant and ſometimes in a deficient ſtate of electricity. One of my ways of proving it is rather diverting, when I have a company of perſons of ſufficient courage to form a circuit, by joining hands in the uſual manner, to receive the charge of the *new Leyden bottle*, as I term it. It is thus performed—The firſt perſon in the circuit is to touch with his finger the bell of the atmoſpheric apparatus which communicates with the earth, and the laſt perſon in the circuit is to approach with his finger the braſs ball which is inſulated. The conſequence is that a denſe ſpark of electricity will iſſue, and at the ſame inſtant the whole company gives a ſudden ſpring, as if they had received the charge of the common Leyden bottle. That the rod is diſcharged by the operation is evident, becauſe the pith-ball electrometer, which is connected with it, collapſes. If the finger of the firſt perſon be continued on the bell, and the finger of the laſt be removed from the ball to give the rod time to charge again and again, (for which purpoſe ſometimes three or four ſeconds are enough,) the company may repeat the experiment as often as they pleaſe. But I have ſometimes obſerved, that even electricians themſelves were too well ſatisfied of the fact to make a ſecond trial.

---

* I conſider Mr. Baldwin's ſituation to be ſimilar to that of the worm and fly in the charged Leyden bottle mentioned p. 72.

When the circumſtances which accompany this phenomenon are well conſidered, it may be diſcovered by ſome ſenſible effects, that the force of an electric charge does not depend at all on the ſhape of the charged ſurface. I conclude therefore, from this fact, as before obſerved, that a cloud over the rod, and the ſurface of the earth under it, may be conſidered as the electrified coatings to the ſtratum of air between them; which, between the bell and braſs ball, is only two inches. This ſmall portion of air is ſometimes diſplaced by a continued ſtream of lightning, very awful to a ſpectator.

Moreover, I infer, from well known electrical phenomena, that when two ſuch highly electrified coatings are once well formed, and the attractive force of their electric atmoſpheres have entered even in a ſmall degree into each other; it is not in the power of the wind to ſeparate and diſperſe them. For as the wind in its progreſſive motion, carries the electrified cloud forward, an equal electric charge, but of a contrary kind, in a ſtate of actual operation on the ſurface of the earth, will alſo move and keep an even pace with it; until either the electric charges become more augmented in the coatings of earth and vapour, or they approach nearer and nearer towards each other, or in their path meet with ſome conducting eminence

nence capable of facilitating their re-union; the conſequence of which will be an exploſion of lightning and inſtant clap of thunder; if not ſome damage to animals, vegetables, or buildings.

Let a perſon's ſituation be where it may, either in the houſe or open field, he is liable in any place to be involved in an electric charge, whether it be ſtationary or moving with the clouds. And when he is ſo involved, he may know nothing at all of it, without proper inſtruments; for reaſons before given. I once found myſelf ſo involved, in a ſmall degree, as I was walking in Hyde Park. I obſerved that the atmoſphere began to aſſume a menacing appearance, and a heavy black cloud being at no great diſtance, I took my pocket electrometer out of its caſe, and held it in my hand, and it inſtantly diverged near one inch. Some drops of rain now fell, I therefore went to my houſe, and I found my high pointed rod ſtrongly charged and the bell of it ringing briſkly.

With regard to danger from the returning ſtroke out of or into a perſon, which happens at the inſtant a flaſh of lightning takes place, I apprehend no painful ſenſation can follow. For, although a man naturally poſſeſſes a very great quantity of electricity, and his natural portion we know may be increaſed or diminiſhed, in a ſmall degree, without harm to himſelf, yet the quality and quantity of his electrical ſtate will always have relation to the place he is in. If he ſtood in the direct path of a flaſh of lightning, moſt likely the event would be fatal; but if he happens to be clear of that, his natural quantity of electricity can undergo no greater change in its denſity or rarity than the diſtrict of earth he ſtands upon, and every thing elſe about him; which I ſuppoſe will be very ſmall. For inſtance, there are but few, if any people, who have arrived to maturity, but have at one time or other been as it were involved in the very blaze of lightning, and have not only ſuſtained no harm, but have actually had no ſenſation at all of a returning ſtroke; yet people ſo circumſtanced are in the moſt proper ſituation to feel a returning ſtroke. But the ſenſations and injury ſuſtained (abating ſudden terror) is generally in the eyes, the moſt ſenſible part of the body. The conſtant moiſture of the eyes, perhaps, may contribute thereto, by facilitating the paſſage of a greater quantity of fluid through them. I imagine, that if it were poſſible to deprive a man of his natural portion of electricity, by a returning ſtroke, or in any other way, or even to ſuper-add a double quantity of the fluid, though his body cannot break like glaſs, yet either way might be fatal to him: and thus I ſuppoſe are people deprived of life by lightning. Mr. Baldwin's ſenſations ſeem to imply thus much. See page 64.

I judge, from ſeveral ſenſible effects, that a certain intenſity of the electric fluid eminently contributes to the well being of animals and vegetables. And I conjecture that the energy of the brain and nerves depends on a proper intenſity of electricity; as the act of reſpiring healthfully depends on a proper intenſity of air. However, to give this conjecture ſome weight, I beg leave to tranſcribe an obſervation on the nerves of the Torpedo, by Mr. John Hunter, F.R.S. read at the Royal Society July 1, 1773. " The magnitude and the number of the nerves beſtowed on theſe organs, in proportion to their ſize, muſt on reflection appear as extraordinary as the phenomena they afford. Nerves are given to parts either for ſenſation or action. Now, if we except the more important ſenſes of ſeeing, hearing, ſmelling, and taſting, which do not belong to the electric organs, there is no part even of the moſt perfect animals, which, in proportion to its ſize, is ſo liberally ſupplied with nerves; nor do the nerves ſeem neceſſary for any ſenſation which can be ſuppoſed to belong to the electric organs, And with reſpect to action, there is no part of any animal with which I am acquainted, however ſtrong and conſtant its natural actions may be, which has ſo great a proportion of nerves.

" If it be then probable that thoſe nerves are not neceſſary for the purpoſes of ſenſation or action, may we not conclude that they are ſubſervient to the formation, collection, or management of the electric fluid; eſpecially as it appears evident, from Mr. Walſh's experiments, that the will of the animal does abſolutely controul the electric powers of its body, which muſt depend on the energy of the nerves.

" How far this may be connected with the power of the nerves in general, or how far it may lead to an explanation of their operations, time and future diſcoveries alone can fully determine."

The powers of the electrical Eel, appear to be very much ſuperior to thoſe of the Torpedo. I have ſeen his brilliant ſparks in the day light, heard their ſnapping noiſe, and felt his ſhocks, which were, on ſome occaſions when he was much diſturbed, very ſevere.

But to purſue our remarks on the ſuppoſed danger from the returning ſtroke a little further. Beſides the evidence of natural facts, ſimilar phenomena attend artificial electricity. When we accumulate denſe electric ſparks, which ſtrike through air, from ſixteen to twenty inches in length, I have felt at thoſe times a motion of the air on my face, at the inſtant thoſe exploſions happened, but I did not feel the return of the fluid into my body, which I had been deprived of during the accumulation. Yet I ſaw electricity returning by the bell wire into the earth within leſs than two inches of its ſurface, and at the diſtance of eighty-three feet from the machine. But in the room next to that in which the exploſions were made, about two yards of the bell wire, in the dark, ſeemed to be on fire by the returning electricity, which was eſteemed a fine ſight by the ſpectators. Now, as no bodily ſenſations were felt, it may be ſuppoſed by ſome that no change of the natural quantity of fluid had taken place on the company; but that is by no means the conſequence; for the houſe itſelf*, and every perſon and thing in it during the accumulation of thoſe ſparks are electrified negatively; which is eaſily proved, by either placing perſons or things upon a good inſulation, the moment before an exploſion happens, as they will be found, on trial, electrified negatively; becauſe whatever electric ſtate they poſſeſſed at the inſtant they became inſulated, the ſame will remain when the exploſion is over.

On the 12th of March, 1781, by the favour of Richard Hen. Alex. Bennet, Eſq. F. R. S. F. A. S. and with his large electrical apparatus, a ſheep was killed by the electrical ſhock, from a very large battery, in the preſence of many members of the Royal Society, aſſembled together for the purpoſe of viewing the operation. In this mode of employing a very great quantity of the electric fluid in one ſtroke, no ſenſation of a returning ſtroke was perceived by the company, who ſtood near to three ſides of the table on which the ſheep lay. It was thought neceſſary by Mr. Hunter (who had the direction of the operation) that the braſs rod, which was to conduct the electric charge to the head of the animal, ſhould be preſſed cloſe to it, or the wool of it might obſtruct the force of the charge. I readily accepted the office, and, with a ſtick that ſtood near at hand, I preſſed the metallic rod tight to its head; although my ſituation in ſo doing was judged dangerous yet I did not feel the leaſt ſenſation.

---

* See the 22d of Auguſt, in the Journal for 1789—page 115.

Dr. Prieſtley, and other perſons, put their hands into the water, at the time that the electric charge of the battery paſſed over its ſurface; and they felt a ſudden concuſſion in the water, without pain to themſelves. He held the bill of a robin red breaſt, and after that the noſe of a mouſe, near the electric exploſion of a large battery, but they did not ſeem to be at all affected by it. I put into a large Leyden bottle a fly, and after that a worm, and then charged the bottle, during which I kept my eye on them, and in the diſcharge alſo, but neither the charge nor diſcharge had any viſible effect upon them.

I will here tranſcribe, in concluding this chapter, a few of the many remarks and obſervations made by that eminent electrician Signior Beccaria, on lightning.

"Conſidering the vaſt quantity of electric fluid that appears in the moſt ſimple thunder ſtorms, he thought it impoſſible that any cloud, or number of clouds, ſhould ever contain it all, ſo as either to diſcharge or receive it; beſides, during the progreſs and increaſe of the ſtorm, though the lightning frequently ſtruck the earth, the ſame clouds were the next moment ready to make a ſtill greater diſcharge, and his apparatus continued to be as much affected as ever; the clouds muſt conſequently have received at one place, the moment that a diſcharge was made from them in another."

"The extent of the clouds doth not leſſen this difficulty; for, be it ever ſo great, ſtill the quantity ought to be leſſened by every diſcharge."

"The ſame cauſe which firſt raiſed a cloud from vapours diſperſed in the atmoſphere, draws to it thoſe that are already formed, and continues to form new ones, till the whole collected maſs extends ſo far as to reach a part of the earth where there is a deficiency of the electric fluid; thither too will thoſe clouds, replete with electricity, be ſtrongly attracted, and there will the electric matter diſcharge itſelf upon the earth. A channel of communication being in this manner found, a freſh ſupply of electric matter will be raiſed from the over-loaded part, and will continue to be conveyed by the medium of the clouds till the equilibrium of the fluid between the two places of the earth be reſtored."

"The fact, therefore, muſt be, that the electric fluid is continually darting from the clouds in one place, at the ſame time it is diſcharged from the earth in another; and it is a neceſſary conſequence from the whole, that the clouds ſerve as conductors to convey the electric fluid from thoſe places of the earth which are overloaded with it, to thoſe which are exhauſted of it."

I am not certain whether Signior Beccaria was ever acquainted with that intereſting diſcovery of Dr. Prieſtley on the Tourmalin, as mentioned in the beginning of this work; but I have often thought that that fact of the Tourmalin gives aid to, or corroborates ſtrongly, Signior Beccaria's ſentiments of the electrical ſtate of the earth during a thunder ſtorm.

As it is now a fact, that ſo ſmall a ſubſtance as the Tourmalin ſtone is, can exhibit at the ſame time, and on the ſame flat ſide, the two ſtates of electricity, why ſhould it be thought impoſſible for the earth to ſuſtain, for a few minutes, (which would be in ſome thunder-guſts quite ſufficient) the two contrary ſtates of the electric fluid? and eſpecially when they are only ſuppoſed to happen on the earth at the diſtance of many miles;—perhaps in ſome thunder-guſts not leſs than 30 or 40.

I readily admit that the earth, even in its dryeſt ſtate, is a better conductor of electricity than the Tourmalin; but when a mile of earth is oppoſed to every twentieth part of an inch of the ſtone, their difference of capacity for conducting the electric fluid is thereby conſiderably diminiſhed.

The only difficulty here ariſes from our want of conceiving how a quantity of electric fluid can lie condenſed in or near the ſurface of the earth, in one part of it, whilſt its neighbouring fluid in another part is attenuated; but when experiment is ſtrongly on one ſide, and nothing but this difficulty of conception appears on the other, the latter ought to give way; and when the thing is carefully conſidered, and experiments with appearances are duly compared, perhaps the difficulty of conception may vaniſh.

CHAPTER VIII.

Containing ſome Experiments and Obſervations on the Leyden Bottle.

I Begin to be afraid that perhaps, after having been conſidered as a dry experimenter, I may be taken for a viſionary innovator of Dr. Franklin's theory. Dr. Franklin's diſcoveries, relating either to the nature of lightning, or to the Leyden bottle, are truly amazing, and much praiſe is juſtly due to his ingenuity. But it is neceſſary to obſerve, that though many of Dr. Franklin's admirers thought that he had exhauſted the whole ſubject, he himſelf was far from thinking ſo; and the hiſtory of electricity, ſince the date of his diſcoveries, demonſtrates that his ſuſpicion was true. Time has brought to light a great number of incomplete as well as complete experiments, and perhaps more of the former than of the latter; ſo that, though we know much more than he did at that period, we, at the ſame time, know how much remains yet unknown.

It has been my endeavour, by the following experiments and obſervations, to aſcertain in a conciſe manner, that every electrical exploſion of the Leyden bottle is the conflux or meeting of two oppoſite powers, the poſitive and negative electricities, ruſhing into union from two oppoſite directions; which I conceive muſt ariſe from two cauſes, that is to ſay, from the ſtrong tendency of the two electricities to re-unite, which attract each other with equal force, and the reſiſtance oppoſed thereto by the non-conducting quality of air.

I conceive that there is only one electric fluid in nature. But when the natural quantity of a body is divided into parts, and ſome of it given to another body having its whole quantity, we give different names to the electrical ſtate of two bodies ſo electrified, becauſe of their conſequent different effects on each other, yet they are one in their nature and operation. The ſuſceptibility of the electric fluid to ſuffer a diviſion or change in its natural ſtate and ſituation is manifeſt in all electrical experiments, but this change cannot be carried on beyond a certain degree without great force or violence, becauſe the divided parts unite their whole force againſt the diſuniting power, and will ſoon become equal to it; therefore it is, that in the charging of glaſs the operation is limited and ſoon ſtops; viz. not becauſe the negative ſide is poſſeſſed of no more electricity, but becauſe the diſuniting and the attracting powers are then actually balanced, conſequently all further progreſs muſt ceaſe.

I am thoroughly ſatisfied of the truth of this general concluſion, that every ſubſtance in nature (except air) has naturally a certain quantity of electricity appropriated to it, which quantity may be diminiſhed, either naturally or artificially, by drawing out a part, which the body will again reſume; but its whole appropriated quantity can never wholly be drawn out of it. And by the bye, the want of attending to this circumſtance has occaſioned many miſtakes, for a ſpark iſſuing from a diminiſhed quantity is as real a ſpark of the electric ſubſtance as the contrary; I therefore infer, that negative electricity muſt be equally as active as poſitive, and that it will urge its way through every reſiſting medium to meet the poſitive; for this reaſon it does not *inactively wait in its place* until the poſitive electricity has ſupplied all its *wants.* This is, I preſume, manifeſt, not only in the foregoing ſeries of experiments on poſitive and negative light and ſparks, but alſo in their atmoſpheres, the conſideration of which would carry me too far for my original deſign.

I am aware that the validity of thoſe facts, and my reaſoning upon them, militate againſt the received *theory* of electricity, becauſe Dr. Franklin, in his firſt letter, aſſerts, and by way of inſtance ſays, "Suppoſe the common quantity of electricity in each part of the bottle, before the operation begins, is equal to 20; and at every ſtroke of the tube, ſuppoſe a quantity equal to 1 is thrown in, then, after the firſt ſtroke, the quantity contained within the bottle will be 21, in the outſide 19. After the ſecond, the inſide will have 22, the outſide 18, and ſo on until after 20 ſtrokes; the inſide will have a quantity of electricity equal to 40, the outſide *none*, and then the operation ends. Here we have a bottle containing at the ſame time a *plenum* of electricity, and a *vacuum* of the ſame fire, &c."

If ever Dr. Franklin wrote his obſervations in haſte, it was in this particular, without having firſt well conſidered the facts and appearances that ſtill remain, and which cannot be accounted for, on the ſuppoſition that one ſide of the bottle was exhauſted of all its electricity; for, to the extent to which we are able to carry this experiment, the poſitive and negative powers of the body are increaſed and not diminiſhed by the operation. Beſides, we will admit that his tube was able to force out of one ſide of the bottle 20 negative ſparks, and this we will ſuppoſe was the limit of its power, yet a greater power would with eaſe force out 20 more, if the condition and ſtrength of the glaſs would bear it. Bodies have no doubt a limited quantity of electricity, which probably may be more or leſs according to the nature of the ſubſtance; but we have never yet found this limit in any, otherwiſe than what the power employed creates, for when more power is applied a greater quantity of the electric fluid will be found.

To exhibit theſe effects as plain as poſſible, and beyond the power of doubt, I would inſulate the Leyden bottle as repreſented figure 5 (a contrivance obvious to every electrician). A repreſents a glaſs ſtand, which ſupports the Leyden bottle, in a ſocket turned out of the wood B.

C is a metallic belt, with a female ſcrew fitted to it, in order that metallic balls and points of different terminations may be occaſionally ſcrewed to it. At a convenient diſtance from the ſide of the bottle is fixed an inſulating pillar of glaſs. A curved wire, with a knob at the lower end of it, is ſcrewed to the metallic rod D, which rod is moveable at pleaſure in the head of the pillar, and is fixed tight in its place by the ſcrew E. Place this inſtrument ſo that the knob of the bottle may be within a quarter of an inch of an equal knob proceeding from the poſitive prime conductor F; the rod D is to be connected by a wire with the negative prime conductor; the knob on the belt, and that on the curved wire, are alſo to be placed a quarter of an inch apart. Things being thus diſpoſed, and motion given to the electrical machine, the progreſſive charge of the bottle may be obſerved with eaſe. The moſt ſtriking effect of this apparatus is, that it viſibly determines the quantity of power that any electrical machine is poſſeſſed of; and it alſo ſhows, in a clear manner, the fallacy of thoſe old doctrines, viz. "that no more electrical fire can be thrown into the top of the bottle when all is driven out of the bottom," a circumſtance that never yet happened in the Leyden bottle; for in all caſes the cauſe of ceſſation of electricity in charging it, is from the electrical machine itſelf, as will plainly appear from the three following experiments.

By managing the ſilk flap of the rubber of my machine I make the glaſs cylinder act ſtrongly or weakly at pleaſure. Having put it into a weak ſtate of action, yet equal to a machine of ſmall power, and the apparatus being adjuſted as before directed, I turn the glaſs cylinder, and count the ſparks which are forced into the bottle until I ſee them ſtop, the number of which in this ſtate of the machine was 49, and of courſe 49 ſparks were forced out of the negative ſide of the bottle. I then increaſed the excitation of the glaſs cylinder, to repeat the experiment, the apparatus remaining as before. I again worked the machine and counted the ſparks, which I found to be 112 before they ceaſed. Laſtly, I made the glaſs cylinder act briſkly; the apparatus remaining as before, the machine was now able to force into the bottle 155 ſparks before there was a viſible ſtop; and at the ſame time, as if it were ſpark for ſpark, there was forced off the negative ſide of the bottle 155 ſparks. This quantity, great as it is, for a bottle whoſe coated ſurface on one ſide is only 80 ſquare inches, is not, I ſuppoſe, the one thouſandth part of the electricity contained in a glaſs of this dimenſion. Nor will glaſs bear a total deprivation of its electricity on either ſurface, this we know by ſad experience, becauſe it is ſure to break long before that happens; however this laſt effect of my machine ſeemed to be its utmoſt power.

From theſe ſeveral facts we may ſafely conclude (notwithſtanding it has been affirmed, "that one ſide of charged glaſs contains a plenum and the other a vacuum of electricity") that we are not yet acquainted with the preciſe quantity of electricity contained in glaſs, or indeed in any other ſubſtance; nor do we yet know of any criterion whereby to determine a total deprivation. For the reſult of theſe experiments, being ſo widely different from what has been conſtantly affirmed, concerning the negative ſide of the Leyden bottle, is a clear proof, that thoſe concluſions were formed too haſtily, having attributed to the power applied, what it was totally unable to effect.

The common criterions of poſitive and negative electricity, on electrified metallic points, are alſo exhibited in a very evident manner by this inſtrument, by only removing the knobs and placing in their ſtead four metallic points, a little flattened at their ends with a ſmooth file; the other parts of the apparatus remaining as in the three preceding experiments. As ſoon as the charge of the bottle begins; the uſual ſigns of both electricities will be viſible, illuminating the points of the interrupted circuit. The ſign on the point connected with the poſitive prime conductor will indicate poſitive electricity, and the ſign on the point oppoſite to it in the knob of the bottle will be faintly negative. The light on the point or extremity of the curved wire will be bright and negative, and the ſign exhibited on the point at the belt will be the poſitive ramified light.

The cauſe of theſe contrary effects ſeems to ariſe from the repulſion of the electric fluid in the firſt caſe, and the reſiſtance of the air in the ſecond. For inſtance, all the time that the bottle is charging poſitively the point on its knob exhibits the negative ſign, contrary to the charge itſelf, which is effected by the repulſive power of the poſitively electrified oppoſite point, which keeps the knob and point in a deficient ſtate of electricity, and of courſe attracts the negative; but this repulſive power extends only to a very ſmall diſtance, and its effect grows leſs and leſs as the charge of the bottle advances, therefore the ſign on this point is a weak one. On the other ſide of the bottle, as ſoon as charging begins, the electricity is driven out of the glaſs into the coating, and becomes condenſed on the point at the belt, even ſo powerfully as to exhibit the poſitive ramified light, though it iſſues from a negatively charged body, which is certainly owing to the reſiſtance of the air to the egreſs of the fluid at that point. Thus we ſee that metallic points, whether they are connected with a body electrified poſitively or negatively, do ſometimes exhibit electric ſigns contrary to the kind or ſource of electricity whence they proceed; yet thoſe ſigns are certain criterions of the kind on the points themſelves.

If the Leyden bottle be charged *without* a viſible *ſpark*, then, in that caſe, the electricity during the charging has but one direction, viz. from the negative to the poſitive ſide of the bottle; and in the diſcharge of it, the contrary way. But if the charging or diſcharging of it be made through the reſiſting medium of air, conſequently *with* a viſible *ſpark*, in that caſe the direction of the electric fluid is doubled, and the ſpark or light ſeen conſiſts of poſitive and negative light; as the foregoing experiments abundantly confirm. If the charge of the bottle be made at a negative conductor (which is the one I generally uſe) the electric light drawn out at the knob has the poſitive aſpect, notwithſtanding the bottle is actually charging negatively; and ſo it affords an electrical paradox.

During the time that this active agent is in a diſturbed ſtate, which commences by an unnatural diviſion of what naturally exiſts in bodies, no ſtriking phenomenon attends it that is more evident than its conſtant tendency to unite. This tendency is manifeſt by the mutual attraction of the divided parts, which is more conſpicuous in this than in any other fluid; inſomuch, that it does not only exhibit a reciprocal attractive force like a divided portion of water, quickſilver, &c. but it is poſſeſſed of active power; for this fluid takes every proper means to facilitate its re-union, by drawing light bodies into the interrupted path, and crowding or condenſing itſelf at the prominent parts or extremities of all conductors, whether they are blunt or pointed, even ſo forcibly that *each* power will appear to *ſtream forth* from the conducting *ſurface* till they meet near the middle of the interrupted *ſpace*. For there begins the re-union of the two electricities, which ſometimes ends in a full exploſion of their whole divided quantities, and which is inſtantly reſumed by thoſe bodies that had been in ſome ſmall degree deprived of their natural portion of the electric fluid; after which, generally, all ſigns of electricity ceaſe.

This remarkable tendency of the divided parts of the fluid to unite, is often perceived in a *full* charged Leyden bottle; at the upper edge of the outſide coating, and at the edge of the cork in the neck of the bottle: where ſtrong efforts of active light are ſeen. If the inſide of the bottle be charged poſitively, the light which is firſt ſeen is generally the negative, on the outſide, darting upwards ſmall rays of electric light from the edge of the coating, and ſoliciting, as we may ſay, an union with that of the inſide. After this, we generally perceive, as the charge goes on, bruſhes of light iſſuing from the edges of the cork and outſide coating into the air (as if the fluid ſpent itſelf therein, which cannot be but by an act of violence, becauſe that would be to operate againſt itſelf and its known tendency); which will viſibly incline towards each other's atmoſphere, and thereby unite in ſome ſmall degree, and in proportion thereto ſtop the further progreſs of the charge or their further diſunion. But ſhould the power applied be ſuperior to the preſent intenſity of the charge, and the diminution occaſioned by thoſe efforts, the two powers would actually form an external circuit, as repreſented at A, fig. 6, by means of their atmoſpheres, which are already in poſſeſſion of the adjacent humidity of the air, and unite in oppoſite directions in a ſpontaneous exploſion of their whole quantities.

In concluding this chapter I beg leave to obſerve that I have ſometimes been curious enough to electrify a pair of inſulated pith balls poſitively, and another pair negatively, with a view to aſcertain the difference between their attracting and ſtriking diſtance. It is well known that the attracting diſtance is conſiderably greater than the ſtriking one. It was obſerved to be nearly in the proportion of twenty-ſix to one. This was performed in a cloſe room and dry air. But my ingenuous friend, Mr. Gamble, of Bungay, informs me, that in the open field, from an electric kite which he had raiſed, he found the proportion between the length of the ſpark at the metallic knob of the kite, and the attracting diſtance of light bodies from it, to be nearly as one hundred and ſeventy to one.

A LETTER

A LETTER

TO

Mr. A. WALKER,

LECTURER ON EXPERIMENTAL PHILOSOPHY.

DEAR SIR,

I THANK you for your very candid and obliging obſervations in your letter on my manuſcript. You ſay "I write down in haſte the only circumſtance that ſtrikes me as a real objection without having really conſidered that, or any part of your work, with that attention or time it deſerves, but which my manifold occupations will not allow." When you have time, Sir, to read and re-conſider thoſe parts which ſeem moſt obſcure, and ſhould ſtill remain embarraſſed, I will endeavour to clear them of entanglement, by repeating with you any of the experiments, or make any new ones you ſhall propoſe, that you think may afford further light or ſatisfaction to either of us; in the mean while I ſhall take the liberty of making a few obſervations on ſome of your paſſages.

You obſerve, "If we are to underſtand poſitive and negative electricity as only more or leſs, I think your deſcription ſeems to imply two diſtinct principles." Then there muſt be ſome defect in my deſcription. For a *body* having more or leſs than its *natural quantity* of electricity, is completely all I mean by its being poſitively or negatively electrified. That theſe two different ſtates of one fluid, in their ſeveral effects and appearances, ſeem to indicate two diſtinct principles, I readily allow; which has been, I ſuppoſe, the occaſion of leading ſome electricians into a manifeſt error *. Notwithſtanding this we may, I think, reſt ſatisfied that thoſe effects and appearances are already ſufficiently accounted for by the theory of only one electrical fluid.

You add "that electricity is capable of diſturbing electricity through a plate of air, glaſs, &c. driving it off in proportion to its accumulation, I think I underſtand. But if poſitive and negative meet in air and form the flaſh of lightning, they look to me like two principles." Not ſo, Sir, they are only two ſtates of one fluid. For inſtance, if air be condenſed it is ſtill air, or if it be rarified it is no other. And that the electrical fluid is capable of condenſation and rarefaction every experiment of electricity proves. I know of no exception to this general aſſertion, for the rubber and the ſubſtance rubbed always produce denſe and rare ſtates of this fluid. Conſequently ſuch different ſtates of one fluid muſt aſſume different appearances, and produce different effects. Hence, let the appearances be what they may, they are all electrical; therefore a negative ſpark is as real a ſpark of the electric ſubſtance as a poſitive one. Why their meeting in air ſhould alter the caſe, or raiſe any difficulty, I cannot conceive. The two electricities muſt meet and unite ſomewhere, or elſe the equilibrium in nature can never be

restored.

---

* This obſervation ſeems juſt by Dr. Peart's late Book on Electricity.

reſtored. That the two powers meet in air where the greateſt obſtruction to their union lies, is evident, becauſe otherwiſe they could not emit light or flaſh. However, at the moment of ſtriking into each other, they cannot be diſtinguiſhed to be two balls or two flaſhes of light, becauſe of their rapid motion, which ariſes from the reciprocal attractive force of both electricities. So that when they approach each other in air, their powers and appearances are conſiderably augmented, even to the utmoſt efforts of their whole quantities.

When I place the two equal balls to the metallic curved rods (mentioned in the 5th Experiment on Lightning, conſiſting of poſitive and negative light) and examine the exploſive ſparks which rapidly paſs between them, I diſtinctly perceive the uſual ſigns of both electricities in air, and the light in that part of the reſiſting medium where the two powers unite, to be leſs luminous than in any other part, which loſs of light is the natural effect of their re-union.

Some philoſophers, even at this time, conjecture that the electric matter either is or contains phlogiſton. The electrical ſmell remaining on the body ſome time after the ſtroke is given (and which I have obtained alſo in vacuo) ſeems to confirm ſuch ideas. That ſome quality of accumulated electricity ſhould forcibly act through glaſs, which is impervious to the fluid itſelf, and repel its natural electricity on the oppoſite ſide of the glaſs, in the caſe of charging the Leyden bottle, ſeems alſo to give aid to thoſe conjectures. Which are facts that have long been admired, and though moſt, if not all the effects of electricity depend on this property of the fluid, yet I think it has never been very ſatisfactorily explained.

I am confident that you will clearly perceive, that I have hitherto ſtrictly adhered to one ſingle electric fluid; for I always thought that the doctrine of *two fluids*, viz. the *vitreous* and *reſinous*, were not founded in fact, and it has been juſtly exploded; becauſe it would be quite unphiloſophical to admit more cauſes of things than are ſufficient to explain appearances.

Yet it is ſtill true that negative electricity has very much puzzled moſt writers on that ſubject. I think they have ſometimes made choice of terms too ſtrong to denote a negative ſtate of the fluid, ſuch as *exhauſted vacuum*, &c. ſuch terms may have occaſioned the perplexity. For were it true that a body rendered negative (even to the higheſt degree that art can effect it) was actually exhauſted of its natural quantity of electricity, I acknowledge the difficulty to explain effects and appearances would be totally inſuperable. Becauſe it is obſerved, that as the ſuppoſed exhauſtion advances the negative powers increaſe in regular progreſſion with the poſitive. It is not an eaſy matter to illuſtrate the properties of the electric fluid by the powers and properties of any other, becauſe this fluid differs conſiderably from all other fluids. For although negative quantities of other elaſtic fluids poſſeſs great powers at the moment they are rendered negative, yet it is but for a moment; whereas negative electric powers are permanent. You are pleaſed further to add—

"I have read your manuſcript with pleaſure and inſtruction. It contains much new and intereſting matter, but the manner of writing in our effeminate age is more recognized than the *matter.* I am ſorry to ſay, in this particular, your half and half philoſophers will think your pamphlet not elegant enough; ſorry am I that truth ſhould want embelliſhment, but lace and ruffles muſt now ornament every production, or it will not go down. Yet is your mode of communicating your diſcoveries and labours ſimple and eaſy, ſuch as works of that ſort ought to be."

It is true, hiſtory informs us that new diſcoveries are commonly ſlighted on their firſt being made public, becauſe their real uſe and importance is not at firſt perceived, therefore are they ſoon overlooked and laid aſide for the preſent. As a ſtriking inſtance of the truth of this obſervation, and in this branch of ſcience too, I cannot help expreſſing my ſurprize how ſlow ſome hints of improvement have proceeded. Mr. Canton, in the year 1751, publiſhed his diſcovery of a conſiderable improvement of the rubber, by applying ſilk to it, on which he ſpread a ſmall quantity of an amalgama of mercury and tin. It does not appear to have been in general uſe for near twenty years afterwards. Dr. Prieſtley's Hiſtory of Electricity was printed in the year 1767, in which he ſhews the mode of excitation that was then in common uſe, and alſo a great variety of electrical machines, not one of which is deſcribed as having an amalgama of mercury and tin ſpread upon a ſilk rubber.

Another inſtance of the ſlow progreſs of knowledge is, I think, that on the matter of lightning. It is now forty years ſince that Dr. Franklin proved the *ſameneſs* of the electric *matter* with that of *lightning*, by charging the Leyden bottle at the key of his electrical kite. Yet it is obſervable in the writings of ſome modern philoſophers, that they ſtill retain the old form of doctrine on this ſubject, viz. that lightning conſiſts of a ſudden kindling of *nitrous* and *ſulphureous exhalations* carried into the higher regions of the atmoſphere.

I am, Dear Sir,
Your moſt obedient
Humble Servant,
J. READ.

POSTSCRIPT.

That there is ſuch a fluid as conſtitutes the matter of magnetiſm is a truth not to be controverted any more than its properties of attraction and repulſion. Effects can never ſpring up in an invariable and fixed order without the agency of ſome cauſe, whoſe mode of operating is likewiſe regular and conſtant. The cauſe of electrical attraction and repulſion ſeems widely different from that of magnetiſm, becauſe theſe effects depend on bodies being poſſeſſed of an unnatural quantity of electricity. For without this we know not whether the electricity itſelf does either attract or repel other matter. Hence a middle quantity ſeems to poſſeſs no powers.

For inſtance, inſulate three bodies A, B, C, of equal dimenſions, and of the ſame kind of ſubſtance, we will ſay three braſs rods, of courſe their natural quantity of electricity

tricity will be nearly equal in each of them. We will ſuppoſe that the quantity in each rod, before the operation begins, is equal to ten ſmall ſparks. Place the rods A and C in a ſtrait line, with their ends nearly in contact, hold an excited glaſs tube over A, but at ſome diſtance from it, and an electric ſpark naturally reſident in this will be repelled into C, then increaſe the diſtance of the rods to prevent the return of the ſpark, and remove the tube, and C will be found electrified poſitively, having eleven ſparks, and A negatively, having only nine ſparks; A and C will now exhibit the phenomena of attracting and repelling light bodies; the middle or natural quantity in B having its original ten ſparks undiſturbed, ſhows no ſigns of electricity at all. The electric charge in A and C conſiſts only of what was in them before, for their whole quantity of electricity is neither increaſed nor diminiſhed by the operation, though a change has been made in its ſituation. This will be evident if A and C are made to touch each other, by which the equilibrium will be reſtored to both of them; A and C will now like B, exhibit no ſigns of electricity. Theſe effects ſhow moſt plainly that the *cauſe* of electric and magnetic attraction and repulſion is not the ſame.

The magnetic virtue is termed a fluid; and it is ſaid that there are corpuſcles of a peculiar form and energy, which continually circulate around and through a magnet. That the magnetic and electric fluids pervade the pores of metallic matter with equal eaſe is manifeſt, the former that of iron only, the latter of all metals. Though there are ſeveral effects which indicate a ſameneſs between theſe two fluids, yet I ſuſpect that there is hardly any other than the one (which can ſcarcely be accounted one) mentioned above. There is indeed another appearance in magnetiſm which bears a ſtrong analogy to the electrical phenomenon, which takes place when two bodies differently electrified are brought within the ſphere of action of each other. This may be obſerved by bringing the oppoſite poles of two magnetic bars near to each other and ſprinkling ſome iron filings between their ends. With reſpect to their laws of attraction and repulſion they ſeem to me to have no analogy at all, any more than the cauſe determining thoſe appearances. Beſides, we are not yet ſure whether what we term electric attraction and repulſion comes from the electricity itſelf, or from the body electrified, or from both. It appears moſt probable that theſe effects are the combined force of both, as the electric fluid is never known to act alone. It is not, therefore, the cauſe that bodies approach or recede, that is expreſſed by the words attraction and repulſion, but merely the effect itſelf.

The late Mr. Wilſon, F.R.S. could not be perſuaded that the electric appearances of light, and others of its ſenſible qualities, were parts of the electrical ſubſtance; but that they conſiſted of ſmall parts of groſs bodies thrown into ſtrong agitations in the air by the force and action of this fluid paſſing from one body into another, by which they become decompoſed, part with the light (that before lay hid within them) and their moſt volatile particles, and ſo ſhine and ſmell, and explode in paſſing through the air. I always conſidered this as a bold aſſertion, void of proof; and his arguments in ſupport of it rather ingenious than ſolid.

I conceive that the uniformity of the electric effects and appearances evinces the exiſtence of a regular and uniform cauſe, doing the ſame things and exhibiting the ſame appearances under the ſame circumſtances at all times. It therefore ſeems not likely, that the ſenſible qualities of the electric fluid ſhould only be adventitious. Such ideas which reduce the electric phenomena into mere accidental effects and appearances, puſhed ſuddenly into exiſtence for a moment, are unworthy of an electrician.

In order to be ſatisfied in this matter, viz. that Mr. Wilſon's reaſoning, in this particular, does not accord either with the philoſopher himſelf, nor with the electrical phenomena, we need only recur to the electric effects and appearances obſerved in vacuo, where there is none of the ſuppoſed groſs matter for the electric ſubſtance to operate upon, and kindle into light and ſmell; becauſe in that caſe, if his reaſoning was well founded, we ought to expect but little or no light nor ſmell in vacuo. But we know, by experiment, that the caſe is far otherwiſe, for the ſame quantity of electricity exhibits far more light in vacuo than it does in air; and I have obtained the electric ſmell in vacuo, by means of a convenient inſtrument made for the purpoſe. To make it ſtill more evident by an experiment in air. It will appear by the following very ſimple operation that electric light is ſometimes produced without the ſuppoſed agatition in the luminous body. Take a ſtick of hard ſealing-wax and lightly rub it in the dark with a woollen cloth; then lay down the cloth and approach with the end of your finger the rubbed part of the wax and electric light will be ſeen to iſſue out of your finger, and ſpread itſelf on the ſurface of the wax in a beautiful manner. This experiment needs no arguments of mine to inforce it; it is plain and full to the purpoſe, that is to ſay, that the light iſſuing out of the finger is no extraneous ignited matter, and therefore luminous, but it is a part of the proper electrical ſubſtance, iſſuing out of the finger in the form of light, to ſupply a deficiency of it in the wax, occaſioned by the rubbing.

Dr. Prieſtley oberves, in his firſt volume on different kinds of air, page 280—" That the electric matter in paſſing through non-conducting ſubſtances always emits light. This light I have been ſometimes inclined to ſuſpect might have been ſupplied from the ſubſtance through which it paſſes. But I find that after the electric ſpark has diminiſhed a quantity of air as much as it poſſibly can, ſo that it has no more viſible effect upon it, the electric light in that air is not at all leſſened. It is probable, therefore, *that electric light comes from the electric matter itſelf.*"

REMARKS

ON

Dr. Peart's late Book on Electricity.

SINCE the above was written Dr. Peart's book on Electricity has been put into my hands. It contains a new theory of Electricity, " pointing out" (as the Doctor obſerves in the Title Page) " the inconſiſtency and fallacy of the doctrine of *poſitive* and *negative* electricity, and inveſtigating and explaining the true *principles*, *compoſition*, and *properties* of *electric atmoſpheres*."

Notwithſtanding theſe matters have been noticed before in this work, I cannot, however, forbear expreſſing my ſurprize on ſeveral of the Doctor's improper ſtatements of experiments and arguments deduced therefrom, in which he miſtakes the cauſe of ſome particular effects, and thus both himſelf and all his followers are put upon falſe purſuits.

Doctor Peart obſerves, in page 3, " we have *no* right to ſay that any ſimple body is poſſeſſed of electricity unleſs it ſhews ſome ſigns of attraction when a light body is preſented to it." This is ſo abſurd an infringement of truth that it hardly deſerves to be noticed. The Doctor might as juſtly have ſaid that we have *no* right to ſay that a dry bone is poſſeſſed of water, unleſs it ſhows ſome ſigns of wet adhering to the touching body. Had it not been for this peremptory manner of ſpeaking I know not that I ſhould have taken any notice here of his many miſtakes. However, contrary to the Doctor's aſſertion, I think I have a good right to ſay, that every ſubſtance I have tried, except air, (and which are very numerous) is poſſeſſed of electricity; for although the natural electricity reſident in bodies, undiſturbed, does not afford that kind of proof the Doctor requires, yet other proofs, equally deciſive, are always at hand. It is ſo ſelf-evident a truth, that I queſtion whether it does not attend every experiment of electricity; for if I attempt to communicate electricity to a body, the natural quantity of electricity reſident in that body, will be inſtantly put in motion by the attempt, by which motion the body itſelf will become electrified (without friction) with its own electricity, before what I intended to communicate enter it. This fact is well known, and the truth of this obſervation is of general acceptation. See p. 90 and 91.

This fact is clearly manifeſt in the electric charge of the Leyden bottle. Dr. Franklin has fully demonſtrated, beyond diſpute, that the Leyden bottle has no more electricity in it when charged than before, nor leſs when diſcharged, conſequently its electric charge conſiſts of the natural electricity which was reſident in the bottle before the operation begun. This grand diſcovery has ſtood the attacks of eminent philoſophers for upwards of forty years, and will yet, no doubt, ſurvive the late attack of Dr. Peart. Many cogent facts might be adduced of the preſence of electricity in common matter; an attention to brevity, however, renders it neceſſary to forbear enlarging, I will therefore only add, that the Doctor himſelf, in the ſame third page, ſeems to allow the thing I contended for, in theſe words: "All that can be inferred from hence, is, that there is a *ſubtile fluid*, which, in its *natural ſtate*, poſſeſſes no properties by which it is evident to us; but that, by the action of the rubber upon the glaſs, it becomes excited to form an atmoſphere, around the glaſs, capable of attracting light bodies to its ſurface; this fluid, therefore, is *conſtantly* and *univerſally preſent*, but is never electric but in conſequence of a proper excitement."

Page 6. "If ſilk will impart its electricity, by being rubbed upon glaſs, what is the reaſon why it will not impart it to every other body, by being rubbed againſt it, if all are, naturally, in an equal ſtate of electricity?" Who was it that ſaid it will not? For my part I am ſatisfied that it will impart its electricity to any body, as I am of opinion that every kind of friction in bodies produces heat and electricity; but without inſulation ſomewhere (which cannot be ſaid of rubbed glaſs) the fluid of courſe muſt be inviſible. One may ſay in this, as a great perſonage ſaid in another caſe, "No biſhops, no king." No inſulation, no electricity.

Perhaps the following experiment may be adequate to the Doctor's queſtion. To a piece of wood in the wall of my room I fixed a ſmooth iron poker, I then ſtepped upon a well inſulated ſtool, and with either ſilk or woollen in one hand rubbed the iron poker briſkly, at the ſame time I touched with the other hand a ſenſible electrometer, and with pleaſure ſaw the gradual progreſs of the electric charge. It ſeems therefore, from this experiment, that in all caſes, and whatever is the nature of the ſubſtance, friction always produces electricity; and when the effect is not ſenſible, it is only becauſe the electricity is loſt as ſoon as produced. The production of electricity, by means of friction, is analogous to the production of heat by the ſame means.

I do not admire the Doctor's explanation of the Leyden bottle, and I think that his mode of experimenting with it is fanciful rather than judicious. Indeed his obſervations on it, in their preſent form, are rather too vague to conſtitute any definite thing. Page 48. "If a jar, coated as uſual within and without, be placed upon a glaſs ſtand." Why will he place it upon a glaſs ſtand? that is not the proper mode of charging it, except at the ſame time he connects the outſide coating with the negative prime conductor. "Its inner coating" he continues "connected by proper conductors with the prime conductor, and then electrified poſitively, the *inner* coating will acquire a ſmall charge of *poſitive* electricity, which, acting through the glaſs, will *expel* all the *natural* electric fluid from the outſide coating." This I poſitively deny to be the fact; and I plainly perceive, throughout his book, that he takes it for granted, that a body, rendered negative, is actually deprived of all its natural electricity; this I aſſign as one of the Doctor's principal miſtakes. I readily admit, that ſome authors, when treating on negative electricity, have incidentally given too great occaſion for ſuch ideas; and I am ſure he has not dealt ſparingly in the uſe of them. "Which he ſays will therefore be electrified *negatively*.— The queſtion then is, *whether* is the natural quantity of the electric fluid driven, which was expelled from the outer coating?"—In the preſent caſe, as the circuit is but ſmall, I heſitate not to anſwer, it is driven into the inſide of the jar.—"The glaſs ſtand, he adds, could not conduct it away, yet, the outſide coating is, what they call *completely negative*." Theſe particulars contain a manifeſt contradiction; for if his glaſs ſtand be a good inſulation, (of which I am in doubt) and therefore could not conduct electricity, it is abſolutely impoſſible that the jar ſhould become negative on the outſide, but juſt the reverſe; for the electricity will, ſo circumſtanced, act upon the glaſs jar as if it were made of braſs, or any other metal, and conſequently both the inſide and outſide, will be electrified uniformly the ſame in kind with that of the prime conductor itſelf. If he wiſhes to preclude every exception on the account of inſulation, in this experiment, I would adviſe him to ſuſpend his glaſs jar in dry air, to the prime conductor, then work the machine, and I am ſure he will find the reſult as here expreſſed; *provided that he does not, on trying the fact, approach the outſide coating with any thing but what is perfectly inſulated.*

With regard to electric atmoſpheres, ſome have denied their exiſtence, but Dr. Peart has found a double number of them, and which he ſays "is too evident to admit of a doubt about its veracity." With reſpect to myſelf, I conceive that electric atmoſpheres conſiſt of electricity, naturally reſident in the humidity of the air, ſurrounding an electrified body to a certain diſtance; that excited glaſs, for inſtance, repels the electric fluid from it, and conſequently, beyond that diſtance makes it more denſe; whereas excited wax attracts the electric fluid exiſting in the aqueous matter, nearer to it, making it rarer than it was before.

Electric atmoſpheres evidently decreaſe as the diſtance increaſes from the electrified body, but in what ratio of the diſtance ſeems not yet aſcertained. I have been very careful in repeating experiments of this kind on the two electricities, and I find that this law obtains with both powers; had Dr. Peart been thoroughly acquainted with this law of electric atmoſpheres, it might have ſaved him a great deal of labour.

But we will purſue his doctrine of double electric atmoſpheres in a more particular and experimental manner, becauſe Dr. Peart roundly affirms, page 87,—"In ſhort theſe principles, and this theory alone, can rationally explain the phenomena of electricity, which never will be underſtood unleſs they be admitted." But, previous to the performance of experiments, we ought to conſider attentively the ſtate of our apparatus. And to be plain, I do not approve of the Doctor's electrometer to examine judiciouſly things of this kind. He deſcribes it as conſiſting only of one pith ball fixed to a ſilk thread; this I think muſt be very unmanageable. My electrometers conſiſt of two pith balls, ſuſpended by filaments of combed flax fixed to metal, which is ſupported by a glaſs ſtand, covered with hard ſealing-wax. I have ſeveral of this ſort by me, and of different magnitudes, of courſe different in ſenſibility.

Dr. Peart's definition and application of his double electric atmoſpheres takes up a large part of his book, but for the ſake of conciſeneſs I ſhall paſs over many of his ſmaller obſervations, and content myſelf with obſerving, that the Doctor founds his principles of double electric atmoſpheres on two effects, commonly obſerved in them; *viz.* that if a pith ball be brought into the atmoſphere of an electrified conductor, at a remote diſtance from it, the ball is only attracted without any change in its ſtate; but if the ball is made to approach nearer to it, the ball becomes electrified. For the truth of this I beg leave to refer the candid reader to the 23d, and ſeveral of his following pages; but to an electrician, enough has been ſaid already to make it plainly appear, that he builds his theory on a ſandy foundation.

That an electrometer may be immerſed in an electric atmoſphere, and withdrawn out of it unelectrified—and that if it be plunged deeper into the ſame atmoſphere it will acquire an electric charge, is well known to be nothing more than the mere effect of the various intenſity, and that thoſe effects do not happen alike with any two electometers of different ſenſibilities, at the ſame diſtance from the electrified body, yet their electric charge will be of the ſame kind of electricity with that of the body, at every diſtance in which they become electrified.

The following concluſions appear to be deducible from theſe effects: 1ſt. A body is ſurrounded with an electric atmoſphere, whether it be electrified poſitively or negatively; 2d. theſe atmoſpheres decreaſe in their intenſity as the diſtance increaſes from the electrified body, but are abſolutely formed of one kind of electricity throughout, with that of the body itſelf; and 3d. hence it follows, that the

Another inſtance of the ſlow progreſs of knowledge is, I think, that on the matter of lightning. It is now forty years ſince that Dr. Franklin proved the *ſameneſs* of the electric *matter* with that of *lightning*, by charging the Leyden bottle at the key of his electrical kite. Yet it is obſervable in the writings of ſome modern philoſophers, that they ſtill retain the old form of doctrine on this ſubject, viz. that lightning conſiſts of a ſudden kindling of *nitrous* and *ſulphureous exhalations* carried into the higher regions of the atmoſphere.

I am, Dear Sir,
Your moſt obedient
Humble Servant,
J. READ.

POSTSCRIPT.

That there is ſuch a fluid as conſtitutes the matter of magnetiſm is a truth not to be controverted any more than its properties of attraction and repulſion. Effects can never ſpring up in an invariable and fixed order without the agency of ſome cauſe, whoſe mode of operating is likewiſe regular and conſtant. The cauſe of electrical attraction and repulſion ſeems widely different from that of magnetiſm, becauſe theſe effects depend on bodies being poſſeſſed of an unnatural quantity of electricity. For without this we know not whether the electricity itſelf does either attract or repel other matter. Hence a middle quantity ſeems to poſſeſs no powers.

For inſtance, inſulate three bodies A, B, C, of equal dimenſions, and of the ſame kind of ſubſtance, we will ſay three braſs rods, of courſe their natural quantity of electricity

tricity will be nearly equal in each of them. We will ſuppoſe that the quantity in each rod, before the operation begins, is equal to ten ſmall ſparks. Place the rods A and C in a ſtrait line, with their ends nearly in contact, hold an excited glaſs tube over A, but at ſome diſtance from it, and an electric ſpark naturally reſident in this will be repelled into C, then increaſe the diſtance of the rods to prevent the return of the ſpark, and remove the tube, and C will be found electrified poſitively, having eleven ſparks, and A negatively, having only nine ſparks; A and C will now exhibit the phenomena of attracting and repelling light bodies; the middle or natural quantity in B having its original ten ſparks undiſturbed, ſhows no ſigns of electricity at all. The electric charge in A and C conſiſts only of what was in them before, for their whole quantity of electricity is neither increaſed nor diminiſhed by the operation, though a change has been made in its ſituation. This will be evident if A and C are made to touch each other, by which the equilibrium will be reſtored to both of them; A and C will now like B, exhibit no ſigns of electricity. Theſe effects ſhow moſt plainly that the *cauſe* of electric and magnetic attraction and repulſion is not the ſame.

The magnetic virtue is termed a fluid; and it is ſaid that there are corpuſcles of a peculiar form and energy, which continually circulate around and through a magnet. That the magnetic and electric fluids pervade the pores of metallic matter with equal eaſe is manifeſt, the former that of iron only, the latter of all metals. Though there are ſeveral effects which indicate a ſameneſs between theſe two fluids, yet I ſuſpect that there is hardly any other than the one (which can ſcarcely be accounted one) mentioned above. There is indeed another appearance in magnetiſm which bears a ſtrong analogy to the electrical phenomenon, which takes place when two bodies differently electrified are brought within the ſphere of action of each other. This may be obſerved by bringing the oppoſite poles of two magnetic bars near to each other and ſprinkling ſome iron filings between their ends. With reſpect to their laws of attraction and repulſion they ſeem to me to have no analogy at all, any more than the cauſe determining thoſe appearances. Beſides, we are not yet ſure whether what we term electric attraction and repulſion comes from the electricity itſelf, or from the body electrified, or from both. It appears moſt probable that theſe effects are the combined force of both, as the electric fluid is never known to act alone. It is not, therefore, the cauſe that bodies approach or recede, that is expreſſed by the words attraction and repulſion, but merely the effect itſelf.

The late Mr. Wilſon, F.R.S. could not be perſuaded that the electric appearances of light, and others of its ſenſible qualities, were parts of the electrical ſubſtance; but that they conſiſted of ſmall parts of groſs bodies thrown into ſtrong agitations in the air by the force and action of this fluid paſſing from one body into another, by which they become decompoſed, part with the light (that before lay hid within them) and their moſt volatile particles, and ſo ſhine and ſmell, and explode in paſſing through the air. I always conſidered this as a bold aſſertion, void of proof; and his arguments in ſupport of it rather ingenious than ſolid.

I conceive that the uniformity of the electric effects and appearances evinces the exiſtence of a regular and uniform cauſe, doing the ſame things and exhibiting the ſame appearances under the ſame circumſtances at all times. It therefore ſeems not likely, that the ſenſible qualities of the electric fluid ſhould only be adventitious. Such ideas which reduce the electric phenomena into mere accidental effects and appearances, puſhed ſuddenly into exiſtence for a moment, are unworthy of an electrician.

In order to be ſatisfied in this matter, viz. that Mr. Wilſon's reaſoning, in this particular, does not accord either with the philoſopher himſelf, nor with the electrical phenomena, we need only recur to the electric effects and appearances obſerved in vacuo, where there is none of the ſuppoſed groſs matter for the electric ſubſtance to operate upon, and kindle into light and ſmell; becauſe in that caſe, if his reaſoning was well founded, we ought to expect but little or no light nor ſmell in vacuo. But we know, by experiment, that the caſe is far otherwiſe, for the ſame quantity of electricity exhibits far more light in vacuo than it does in air; and I have obtained the electric ſmell in vacuo, by means of a convenient inſtrument made for the purpoſe. To make it ſtill more evident by an experiment in air. It will appear by the following very ſimple operation that electric light is ſometimes produced without the ſuppoſed agatition in the luminous body. Take a ſtick of hard ſealing-wax and lightly rub it in the dark with a woollen cloth; then lay down the cloth and approach with the end of your finger the rubbed part of the wax and electric light will be ſeen to iſſue out of your finger, and ſpread itſelf on the ſurface of the wax in a beautiful manner.

When I find that the moiſture in the air has ſo much injured the inſulation of my high pointed rod, that it will not retain a weak electricity, in that caſe I make uſe of my hand exploring rod, which is about the length and thickneſs of a common fiſhing-rod, with plenty of ſmall wire twined round it from end to end. The method of uſing it is ſimple and eaſy. A repreſentation of it may be diſtinctly ſeen in fig. 2. Having firſt *warmed* the glaſs legs of the ſtool, I place myſelf upon it, and raiſe the rod into a vertical poſition, keeping it ſo for a minute or two; I then with a finger of the other hand touch a ſenſible electrometer, and if the threads open it is ſufficient. But ſhould the electrical ſtate of the atmoſphere be too weak to produce that effect, which ſeldom happens, then in that caſe I add to the rod a *lighted torch* T, and place it as remote from my hand as the ſtrength of the rod will bear, and repeat the experiment; thus circumſtanced, it has never yet failed me.

It will be neceſſary juſt to mention the method I have purſued in forming the Journal of Atmoſpherical Electricity. This has been principally by means of the ſigns exhibited by the pith balls O, connected with the rod, When I find theſe cloſed, and attracted on the approach of my finger, yet not ſufficiently charged to repel each other, I write weak ſigns of electricity. When I find the balls open, and, on the approach of excited glaſs, the balls cloſe, I write they are electrified poſitively; but, if the balls open wider, I write they are electrified negatively; and the reverſe when I uſe ſealing-wax. When the balls diverge one inch and upwards, viſible ſparks may be drawn at the braſs ball N. When ſparks are ſaid to have been perceived in any obſervation, I have generally on that account omitted to note the variable quantities of divergency in the pith balls. Their utmoſt limit of regular divergency ſeems to be about five or near ſix inches; above that they are unſteady and diſorderly. The pith balls are near two-tenths of an inch in diameter, ſuſpended by very fine flaxen threads (in the ſtate it is in from the heckle) five inches long. When I mention the diſtance of the balls in tenths of an inch, it is to be underſtood as nearly ſo as my eye can determine.

This apparatus requires a conſtant attention, eſpecially during a diſturbed ſtate of the atmoſphere. From the room in which the apparatus is placed I am ſeldom abſent one hour, excepting the time of ſleep; but, when I leave it, the laſt thing I do at night is to examine the ſtate of the electricity, and, if I find the rod unelectrified, I then place the Leyden bottle on the table S, with its knob nearly in contact with the ball N. The next morning, if I find this bottle charged, I write the kind of electricity it is charged with againſt the day in the Journal, and add, *by the night bottle.*

It is preſumed, that the table is ſufficiently obvious. The column for poſitive and negative electricity is uſed only for the firſt obſervation of each day. I uſe Farenheit's thermometer, ſuſpended on the north outſide of a bow-window. The time of making the obſervation with it, and the barometer, and alſo of the direction of the wind, has uſually been nine o'clock in the morning.

Laſtly, it may be uſeful to obſerve, that I have always found, when the rod is highly electrified, the lower though *uninſulated* part of the apparatus, *viz.* the metallic connection of the bell P with the moiſt earth) to be in a contrary ſtate of electricity to the upper and inſulated part. See the 22d of Auguſt, 1789.

Having made a memorandum of the ſeveral thunder-ſtorms which have happened in divers parts of this iſland, according to information by letters, and from newſpapers, I thought it uſeful to inſert them in this Journal, in order to ſhow whether ſome contemporaneous appearances in my apparatus might not be attributed to them.

Days	Wind	Barom.	Ther.	Sparks	Kind.	MAY, 1789.
		Inch.	°			
9	NW	30.	63	—	Neg	Balls open about three-tenths of an inch.
10	SW	30.15	60	—	Neg	But very weak.
11	E	30.24	61	—	Neg	Barely ſufficient to ſeparate the balls.
12	E	29.91	60	S.	Neg	The firſt day I have had viſible ſparks; weather cloudy, but fair.
13	E	29.91	61	S.	Poſ.	The weather in the forenoon a little hazy; in the afternoon a thick fog. Four o'clock a little rain fell; the rod now became highly electrified poſitively; and the bell rang briſkly: I now filled ſeveral bottles with the fluid. This ſtrong charge in the rod did not laſt more than one hour, but it remained charged poſitively in a leſs degree the reſt of the day. There was this day ſome lightning and thunder at Saliſbury, and to the weſt of it.
14	SE	30.	56	—	Poſ.	Balls open four-tenths of an inch.
15	E	29.66	58	S.	Poſ.	A.M.—And P.M. negative
16	SE	29.83	61	—	Neg	A.M.—And P.M.
17	S	29.91	58	—	Neg	Balls open ſix-tenths of an inch.
18	SW	29.91	57	—	Neg	Balls open five-tenths of an inch.
19	N	30.20	54	—	Neg	P.M. dark heavy weather.
20	SE	30.15	56	S.	Neg	The rod has been electrified nearly the whole day.
21	E	30. 2	54	—	Neg	Nearly the ſame as the preceding day.
22	S	29.89	58	—	Poſ.	Juſt ſufficient to indicate the kind. Serene weather.
23	S	29.90	59	—	Poſ.	
24	SE	29.75	60	—	Poſ.	
25	E	29.68	62	—	Neg	Six o'clock A.M. Soon after a fog with drizzling rain, by which the rod became electrified poſitively.
26	NE	29.64	61	—	Neg	A.M.
27	SW	29.65	60	—	Neg	A.M. Balls open three-tenths of an inch.
28	SW	29.86	60	—	Poſ.	But very weak.
29	W	29.72	61	S.	Poſ.	A very cloudy morning, though at too great a height for my rod; but in the afternoon the clouds approached much nearer, and the rod became charged pretty ſtrongly poſitive, which continued about one hour and a quarter. I charged ſome Leyden bottles with the fluid, ſome poſitive, others negative, for there were four gradual changes of the electricity.
30	S	29.70	56	—	Poſ.	Balls open half an inch.
31	SW	29.57	58	S.	Poſ.	Nine o'clock A. M. a heavy ſhower of rain, by which the rod became ſtrongly charged with negative electricity, all the time the ſhower laſted, which was ſhort and ſudden. One hour afterwards, the electricity changed to a ſtrong poſitive, the bell ſuddenly began to ring, and con-

Days.	Wind.	Barom. Inch.	Ther.	Sparks	Kind.	June.
						tinued to do ſo five minutes; the pith balls then cloſed ſlowly, and opened negative, and continued ſo the reſt of the day. At Edinburgh, ſome lightning and thunder this day.
1	SW	29.71	53	S	Poſ.	A cloudy ſhowery morning. The electrical operations in the rod have been beautiful this day. In about ſix hours time I obſerved ſeven changes of the electricity; five of theſe changes were gradual. The balls opened from 3 to 4 inches, and remained ſo from 15 to 20 minutes each opening, then gradually cloſed; the other two charged ſlowly, but cloſed very quick.
2	SW	29.85	63	—	Poſ.	But weak.
3	SW	29.92	62	—	Poſ.	A.M.
4	W	29.42	52	S	Poſ.	A cool cloudy morning. The rod has been ſtrongly electrified full ſeven hours; the reſt of the day but weakly ſo. There were 12 changes of the electricity, all gradual, except one, which was inſtantaneous; the balls ſometimes exhibited a waving motion, and ſometimes ſudden jerks. There were ſeveral ſhowers of rain, and two of hail; during the fall of hail the rod was moſt powerfully electrified, and the bell rang very briſkly; the effects and appearances were ſo awful, that I kept at a good diſtance from the rod. A great deal of lightning on the eaſt ſide of Kent and Eſſex this day.
5	NW	29.52	5	—	Neg	Balls open half an inch.
6	W	29.78	53	S	Neg	A.M.—And P.M. poſitive. There were ſmall ſparks emitted from the braſs ball N, and the pith balls continued cloſing and opening many times, without any change of kind, for the ſpace of two hours.
7	NW	29.92	52	—	Neg	Balls open from one to ſeven-tenths of an inch.
8	NW	30.18	50	—	Neg	
9	NW	30.12	57	—	Neg	
10	NW	30.25	56	—	——	Weak ſigns, balls not open.
11	NW	30.12	55	—	——	
12	E	30.25	56	—	Poſ.	Balls open three-tenths of an inch.
13	E	30.28	54	—	Poſ.	Balls open five-tenths of an inch.
14	NE	30.19	51	—	Neg	Very cloudy weather, but at too great a height to affect the rod powerfully.
15	E	30. 4	56	—	Neg	Balls open full half an inch.
16	E	29.90	60	—	Neg	Balls open near one inch.
17	S	29.81	62	S	Poſ.	Ten o'clock A.M. a ſudden ſhower of rain, by which the rod became highly electrified poſitively, and continued to emit

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June.
		Inch.				ſmall ſparks at the ball N, long after the ſhower was over, without any change of the electricity.
18	SE	29,89	60	S.	Poſ.	The weather ſhowery; the rod pretty well electrified.
19	SW	29.88	56	—	Neg	Balls open ſix-tenths of an inch.
20	SW	29.65	63	—	——	Weak ſigns; balls not open.
21	SW	29.71	59	S.	Neg	This morning ſeveral heavy clouds paſſed over from the SW, by which the rod became moderately electrified negatively; and ſome rain fell, which increaſed its electrical charge. In the afternoon, the wind and clouds put on a more ominous appearance; near five o'clock began a ſtorm of wind, rain, lightning, and thunder; but the main weight of the ſtorm did not come near my rod. Its dire effects muſt be eaſt of London: nevertheleſs, I had thoſe uſual beautiful appearances which attend a ſtrong charge in the rod. The ſtorm laſted one full hour, during which time there were five ſucceſſive changes of the electricity, viz. four gradual attended with ſudden jerks or ſtarts, which often diminiſhed the divergency of the pith balls from 4 inches to 2 inches or leſs. After thoſe jerks the pith balls recovered their former degree of divergency, ſometimes ſuddenly, and at other times ſlowly. The other change happened inſtantaneouſly, the pith balls collapſing and opening ſo quick that the eye could barely ſee their motion. There were two other inſtantaneous cloſings and openings of the balls, without a change of electricity. Much lightning at Graveſend to day.
22	SW	29.49	56	S.	Poſ.	The rod has been electrified all this day.
23	SW	29.54	57	S.	Poſ.	Moſt of the forenoon. Afternoon ſome rain fell, and the rod became electrified negatively, and ended poſitively.
24	SW	29.60	61	—	Neg	A.M.
25	NW	29,64	55	S.	Neg	A very thick cloudy morning. The electric charge in the rod has been moderately ſtrong and very fine to-day. There were five gradual changes of the electricity.
26	W	29.80	53	—	Neg	A.M.
27	W	29.96	52	S.	Poſ.	Cold ſhowery weather. Except ſome ſmall intervals, the rod has been ſtrongly electrified all this day. The bell rang briſkly for a few minutes, then ſuddenly ſtopped,

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June and July.
		Inch.				and the pith balls cloſed and opened negatively, and continued ſo till a little after eight o'clock P.M. when they changed to poſitive. At Liverpool, this day, a tremendous ſtorm of lightning, thunder, hail, and rain.
28	W	29.70	50	S.	Neg	A very cold, ſhowery morning, and the drops of rain were very large. The rod has been very powerfully electrified near twelve hours this day, during which time there happened eleven changes of the electricity, all gradual but one. The balls often exhibited a waving pendulous motion, without any dimunition in their divergency. There were alſo a few of thoſe jerks before noticed on the 21ſt inſt.
29	W	29.90	51	S.	Neg	The bell rang briſkly: there has been no change in the electricity this day.
30	NW	30.10	53	—	Poſ.	Nearly all day. Weather ſerene and clear.
1	N	29.19	76	—	——	Weak ſigns, balls not open. An even dark ſky, but fair.
2	N	30. 3	76	—	——	
3	N	30. 2	79	—	Poſ.	Weather ſerene, very hot, and a clear ſky.
4	N	30. 2	80	S.	Poſ.	A.M.—And P.M. negative. At Glaſgow, ſome lightning and thunder.
5	NE	29.19	74	—	——	Weak ſigns. Balls not open.
6	NE	29.17	72	S.	Neg	A heavy dark atmoſphere, but fair. At Monkſilver, near Bath, much lightning and thunder.
7	NE	29.16	69	—	——	Weak ſigns of electricity; balls not open.
8	NE	30.	60	—	——	
9	NE	29.40	72	—	——	
10	NE	29.20	72	—	Neg	A.M.
11	E	29.15	74	—	Neg	A.M.
12	E	29.13	78	—	——	Balls not open.
13	W	29. 5	72	S.	Neg	A.M.—And P.M. poſitive, with ſparks. At Hereford, this day, a ſtorm of rain, lightning, and thunder.
14	SW	29. 6	69	—	——	Weak ſigns; balls not open.
15	NW	28. 8	52	S.	Neg	A.M.—And P.M. poſitive, with bright ſparks. At Strichen, in Scotland, a heavy thunder ſtorm.
16	W	30.	60	—	——	Balls not open. At Edinburgh, this day, ſome lightning and thunder.
17	SW	29.10	65	S.	Neg	P.M. with fine ſparks; but no change of kind. At Glaſgow and Hamilton, this day, lightning, thunder, hail and rain; and alſo at Newcaſtle, in Northumberland, the ſtorm was ſevere.
18	SW	29.15	59	—	——	Weak ſigns; balls not open.
19	W	29.10	50	—	Neg	P.M.

Days.	Wind.	Barom Inch.	Ther.	Sparks	Kind.	July.
20	NW	29.10	54	S.	Neg	Three o'clock P.M. I ſaw a thunder ſtorm approaching. While the ſtorm remained at a conſiderable diſtance, the rod was very highly charged with negative electricity, and continued ſo three quarters of an hour; during that time diſtant thunder was heard. The wind ſuddenly ſhifted to the SE, and a very heavy rain ſoon came on; the electricity now changed to poſitive, and the bell rang briſkly; every appearance (both within and without the room) was tremendouſly awful. I therefore ſeated myſelf upon a large inſulated ſtool, where I could with ſafety obſerve the apparatus. A Leyden bottle was undeſignedly placed with its braſs knob near to the braſs ball N. This bottle charged and ſpontaneouſly diſcharged almoſt as quick as I could notice them; and at the ſame time there was a continual flaſhing of denſe ſparks between the bell and braſs ball. Theſe very grand appearances only laſted ten minutes, and the ſcene was terminated by a clap of thunder; but the ſtorm, and its effects on the rodd laſted near two hours. I ſaw no lightning but what was in the apparatus. There were nine gradual changes of electricity. The pith balls exhibited ſudden ſtarts or jerks, and ſometimes a waving motion.
						I had purpoſely placed a large glaſs bowl, upon an inſulated table, in the open air, to catch the falling electrified rain. As ſoon as the bottom of the bowl was well covered with the rain water of the above ſtorm, to my great ſatisfaction, a pair of linen threads I had placed for the purpoſe diverged near two inches; the water remained electrified near ten minutes after it was taken into the houſe.
21	SW	29.15	52	S.	Neg	P.M. a little rain fell, and the electricity changed to poſitive. At Edinburgh and Bamff, this day, there was much lightning and thunder.
22	SW	29.10	61	S.	Neg	A very ſtrong electricity in the rod all the forenoon. 12 o'clock ſome rain fell, on which the rod became highly charged poſitively, the bell rang weakly for a long time, it then ſtopped, and the balls cloſed and opened negative, and continued ſo

Days.	Kind.	Barom	Ther.	Sparks	Kind.	July and Auguſt.
		Inch.	°			full three hours. This day, near Shrewſbury, a ſtorm of rain, lightning, and thunder.
23	W	29.10	51	S.	Poſ.	Both A.M. and P.M. and ended negative as the preceding day.
24	W	29.15	71	S.	Neg	A.M.—And P.M. poſitive.
25	W	29.20	71	—	——	Weak ſigns; balls not open. An univerſal cloudy dark ſky.
26	W	29.10	69	—	——	
27	N	29.15	64	S.	Neg	Four o'clock P.M. happened a ſudden and ſhort ſtorm of wind and rain, by which the rod became powerfully electrified, the bell rang for 20 minutes, then ſtopped, and the electricity became poſitive, and ſtrong. At Cambridge, this day, a tremendous ſtorm of lightning and thunder.
28	N	29.20	74	—	Poſ.	A.M. balls open five-tenths of an inch.
29	W	30.	56	S.	Neg	A.M.
30	NW	29.30	73	—	Neg	Balls open ſix-tenths of an inch.
31	W	29.20	75	—	Neg	P.M.—A regular dark ſky, with ſmall rain, which continued four hours; ſuch rains are never electrified ſtrongly. Air is very moiſt.
1	W	29.79	60	—	——	A heavy dark atmoſphere, and a warm ſoft air. The electricity theſe ſix days amounts only to weak ſigns, balls not open.
2	W	30.12	56	—	——	
3	SE	30.	62	—	——	
4	E	30. 5	61	—	——	
5	E	29.79	66	—	——	
6	SW	30. 9	60	—	——	
7	W	30.27	56	—	Neg	P.M.
8	W	30.24	58	—	Neg	A.M
9	E	30.20	66	—	Neg	A.M.
10	E	30.17	60	—	Neg	A.M.
11	NE	30.20	66	—	——	Balls not open.
12	E	30.16	58	S.	Poſ.	P.M.—A fine ſhower of rain, on which the rod became pretty well electrified; but ſoon changed to a ſtrong negative electricity, which afforded fine ſparks at the braſs ball N. The pith balls cloſed and opened ſeveral times, without any more changes of kind.
13	E	30.14	60	S.	Poſ.	A.M.
14	NE	30.13	62	—	Poſ.	A.M. balls open ſeven-tenths of an inch.
15	NE	30. 9	59	S.	Poſ.	A.M.—2 o'clock P.M. a very black cloud paſſed over the rod, by which it became very ſtrongly electrified for a few minutes only; the bell rang briſkly.
16	N	30.15	62	S.	Poſ.	There has been much rain to-day, and the drops very large. The rod has been in high charge great part of the day. The ſparks at the braſs ball N were very pungent, not only ſo, but alſo the air in the

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	Auguſt.
		Inch.	°			
						room, and the uninſulated bell, and other things, ſhewed that they were electrified. The bell rang briſkly at three intervals of time. This ſtrong charge of the rod continued full four hours; and the electricity, during that time, changed in kind ten times. Eight of them were gradual, two of them were quick and attended with jerks. I heard ſome rumbling of thunder at a great diſtance. At Dunwich, in Suffolk, this day, much lightning and thunder.
17	NE	30.26	61	S.	Neg	A.M.
18	NE	30.32	61	—	Neg	Balls open nine-tenths of an inch.
19	NE	30.25	60	—	——	Weak ſigns; balls not open.
20	E	29.95	63	—	——	
21	SE	29.75	63	S.	Neg	Four o'clock P.M. a ſtrong charge in the rod, but of ſhort duration.
22	W	29.75	56	S.	Neg	The rod was in high charge ten hours this day, except a few ſmall intervals; there were nine gradual changes of the electricity, from negative to poſitive, and the contrary. The bell rang very briſkly at three different times during that period. There were ſeveral ſhowers of rain, and one of hail; during the latter, the electric charge in the rod was moſt intenſe; the ſparks darted between the ball and bell extremely ſharp and quick. I found the moiſture in the air of the room was now electrified, alſo the bell, and its metallic connexion with the earth, and even the bricks in the wall to which the metal is faſtened were all electrified with an electricity contrary to that in the inſulated part of the apparatus. An electrician (who had often in vain called at my houſe to ſee the apparatus in high charge) placed his left hand on the bell, and with his finger of the right hand approached the ball N; a denſe ſpark iſſued to it, and he received a ſmart ſhock in his arms and breaſt, like that of the Leyden bottle. We then joined hands, and made the circuit in the uſual way, between the bell and ball, and we both received a ſevere ſhock. Much lightning and thunder this day at Stirling and Dumfries, in Scotland.
23	W	29.94	52	S.	Poſ.	A.M.—And P.M. negative on a fall of rain.

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	Auguſt and September.
			°			
24	NW	30.15	58	S.	Poſ.	Great part of the day.
25	SW	30.19	60	—	Poſ.	A.M. but very weak in the afternoon.
26	SW	30.10	58	—	——	Weak ſigns; balls not open.
27	N	30. 8	50	—	——	
28	W	30. 3	54	—	Poſ.	A.M. a ſerene clear ſky.
29	SE	29.90	58	—	——	Only weak ſigns.
30	SW	29.80	60	—	——	
31	NW	29.75	62	—	Neg	P.M. from a ſhower of rain, the drops of which were very large. The electricity ſoon changed to poſitive. Though every circumſtance was favourable for a ſtrong electrification, yet the charge in the rod was but weak. My ſuſpicion led me to try the ſtate of the uppermoſt end of the rod, and I found it to be in a contrary ſtate of electricity to that at the lower end of it; the middle part of the rod was in its natural ſtate, that is, ſhewed no ſigns of being electrified; therefore the rod was only (at this time) influentially electrified.
1	SE	29.72	58	—	Neg	A.M.
2	S	29.60	66	S.	Poſ.	A.M. 2 o'clock P.M. a ſhower of rain fell by which the charge in the rod became negative.
3	S	29.50	69	S.	Poſ.	In the forenoon. One o'clock P.M. roſe a ſtrong gale of wind, I now ſaw thunder clouds forming at a great height. Half after five o'clock appearances were dreadful; in five minutes time the ſtrong gale of wind became a ſtorm from SE. This ſtorm of wind (for there was but little rain) carried the large black clouds to the NW, and there I ſaw abundance of red lightning a little above the horizon, and I once heard a rumbling of thunder. The electric ſtate of the rod before the ſtorm was poſitive, but by it was changed to negative, and continued ſo during the whole time, but often varied in ſtrength, ſometimes weak, ſometimes ſtrong. At Amerſham, in Buckinghamſhire, and at the ſame time at the Earl of Aylesford's park, near Packington, in Warwickſhire, was a moſt tremendous ſtorm of hail, rain, lightning, and thunder from four to ſix o'clock P. M.
4	SE	29.50	68	S.	Neg	P.M. There were four gradual changes of the electricity in two hours.
5	SW	30.	69	S,	Neg	P.M. There has been a little rain to-day.

Days	Wind	Barom	Ther.	Sparks	Kind.	September and October.
		Inch.				
6	SW	29.95	59	S.	Poſ.	In the forenoon, and near ſun-ſet negative by ſome ſmall rain.
7	SW	30. 3	62	—	Poſ.	A.M. by the night bottle, and likewiſe by the rod the ſame, but very weak.
8	SW	30.15	67	—	—	Only weak ſigns of electricity; balls not open.
9	SW	30.15	68	—	—	
10	SW	30.12	68	—	—	
11	N	29.95	61	—	—	
12	N	30.10	54	—	Poſ.	By the night bottle.
13	W	30.10	54	—	—	Weak ſigns; balls not open. A dark atmoſphere.
14	SW	29.85	60	—	—	
15	W	29.82	48	—	—	
16	SW	29.74	48	S	Neg	A.M. There were ſeveral heavy clouds paſſed from the SW. by which the rod was highly charged with poſitive electricity, The bell rang briſkly. This charge continued from a little before 11 o'clock A.M, to full ſix o'clock P.M. during that time there were four gradual changes of electricity.
17	NW	29.92	44	—	Neg	By the night bottle,
18	NW	29.61	52	—	Neg	A.M. a more tranſient viſit of the electric fluid I never before ſaw, only while a ſmall black cloud paſſed over the rod, and let fall a few drops of rain; the whole time of the charge was about four minutes.
19	W	29.40	48	—	Neg	A. M. by the night bottle. The electrification of the rod very weak.
20	W	29.40	60	—	—	Weak ſigns; balls not open.
21	W	29.40	60	S.	Neg	A.M. by the night bottle. Five o'clock P.M. the rod was electrified negatively.
22	NW	30. 9	51	—	Neg	By the night bottle, and the rod alſo.
23	NW	30. 2	51	—	Neg	The electrical charge in the rod has been very weak theſe eight days, only juſt ſufficient to iudicate the kind.
24	NW	30.23	61	—	Neg	
25	NW	30.26	49	—	Neg	
26	S	30.26	49	—	Neg	
27	SW	30.	61	—	Neg	
28	W	30.	51	—	Neg	
29	S	29.71	58	—	Neg	
30	S	29. 1	48	—	Neg	
1	SW.	29,22	53	S.	Poſ.	A.M. by the night bottle, which was ſufficiently charged to give a bright ſpark on making the circuit. At noon ſome rain fell, by which the rod became electrified negatively, and very ſtrong, which laſted full four hours; during that time, the electricity changed four times, which were all gradual.
2	SW	29,28	47	S.	Neg	A.M. Four o'clock P.M. the rod was electrified poſitively, and afterwards nega-

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October and November.
		Inch.				
						tively, with ſtrong ſparks at the braſs ball N.
3	SW	29.11	48	S.	Poſ.	A.M. but more intenſely poſitive in the afternoon; the bell for a ſhort time rang briſkly, after that faintly, then ſtopped, and the electricity changed to negative, which continued ſo ſome hours, then declined gradually to weak ſigns only.
4	W	29.40	51	—	Poſ.	A.M. by the night bottle.
5	S	29.53	45	S.	Poſ.	A.M.—And P.M. negative.
6	S	29.50	56	S.	Poſ.	A.M.—Three o'clock P.M. poſitive, but much ſtronger than in the morning. There has been to-day a cold ſmall rain. The electricity changed four times in two hours. This day, at Whitehaven and Lancaſter, was much lightning and thunder, rain, hail, &c.
7	W	29.27	45	S.	Poſ.	A.M. but in the afternoon a much ſtronger poſitive charge.
8	E	29.20	48	—	Poſ.	A.M.
9	SW	29.29	46	—	Poſ.	A.M.
10	SE	29.50	45	—	Poſ.	A.M.
11	SE	29.80	49	—	Poſ.	A.M.
12	S	29.46	53	—	—	Weak ſigns; ball not open. Dark, hazy weather.
13	N	29.50	53	—	—	
14	W	29.50	53	—	—	
15	W	29.52	56	—	—	
16	W	29.67	42	S.	Poſ.	A.M. juſt ſufficient to emit viſible ſparks.
17	W	29.90	40	—	Poſ.	P.M. by means of a fog.
18	S	29.67	52	—	—	P.M. Balls open ſix-tenths of an inch.
19	S	29.79	50	—	—	Weak ſigns. Balls not open.
20	SW	29.75	58	—	—	
21	S	29.89	53	—	Poſ.	A.M.
22	W	30. 4	50	—	—	Weak ſigns of electricity; balls not open. Dark, hazy weather, and moiſt air, theſe eight days.
23	NE	30. 7	53	—	—	
24	E	30.24	48	—	—	
25	NE	30.28	55	—	—	
26	E	30 27	47	—	—	
27	E	30.27	45	—	—	
28	E	30.30	40	—	—	
29	N	30.13	46	—	—	
30	E	30. 3	40	—	Poſ.	P.M. by means of a little cold rain.
31	N	29.92	40	—	Poſ.	P.M. a very high north wind.
1	N	30.32	38	—	—	Only weak ſigns of the electric fluid; balls not open. A dark cloudy atmoſphere.
2	N	29.59	46	—	—	
3	S	29.19	39	—	—	
4	SE	29. 3	48	—	—	
5	S	29.29	50	—	—	
6	W	28.82	48	—	—	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November.
7	W	28.90	43	S.	Neg	A.M. by a ſhower of ſleet, which for a ſhort time occaſioned the rod to emit bright ſparks at the ball N.
8	NW	29. 9	40	—	Neg	A.M. by the night bottle.
9	W	29.29	30	—	Neg	
10	W	29.90	37	S.	Poſ.	A.M. by means of a fog.
11	W	29.98	39	S.	Neg	A.M.
12	SW	29.70	45	—	Poſ.	P.M. This was obtained in the following manner. Soon after ſun-ſet I perceived a light-coloured dewy vapour ariſe 20 or 30 inches above the ground in the park; the evening being ſerene and fair, I ſtood upon an inſulated ſtool, and waved my exploring rod among the dewy vapour, and with my finger touched a ſenſible electrometer, which inſtantly opened with poſitive electricity*. As the evening advanced, a ſtrong fog filled the air; when it was of ſufficient height for the high or fixed rod, this alſo became electrified with the ſame kind of electricity which I had received near the earth's ſurface.
13	W	29.73	40	—	——	Weak ſigns only; balls not open.
14	SW	29.63	46	—	——	
15	SW	29.42	47	—	——	Notwithſtanding all my care and attention to my pointed rod, it has this day been intirely fruſtrated; for I have not perceived any ſigns of the electric fluid. However, it is the firſt day that it has wholly failed me. A moiſt air has prevailed for many days; and there have been ſix hours drizzling rain to-day, which muſt leſſen the exactneſs of the inſulation of the rod, and air alſo.
16	SW	29.43	43	—	——	Weak ſigns; balls not open.
17	S.	29.54	47	S.	Neg	A.M. ſmall ſparks were obtained from the rod, the greateſt part of this day.

---

* When I find that the moiſture in the air has ſo far injured the inſulation of my high-pointed rod, that it will not retain a weak electricity; in that caſe, I make uſe of a ſmall rod which I hold in my hand, and which I ſometimes project through an upper window; having firſt warmed the ſtool legs, I place myſelf upon it, &c. I find this method to be a good ſubſtitute in damp weather. A repreſentation of the rod, and mode of uſing it, may be ſeen in fig. 2.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November and December.
		Inch.				
18	S	29.51	40	—	Poſ.	A.M. by means of a fog.
19	S	29.69	43	—	Poſ.	
20	W	29.65	47	—	Poſ.	
21	NW	29.86	44	—	Neg	A.M. by the night bottle, which I found well charged.
22	N	29.89	44	—	——	Weak ſigns only.
23	NE	30.12	42	—	——	No ſigns. This is the ſecond failure. A moiſt atmoſphere.
24	NE	30.29	41	S	Poſ.	From fog, viſible ſparks were obtained during the greateſt part of the day.
25	N	30.20	37	—	Poſ.	A.M. by means of a fog.
26	N	30.30	37	S	Poſ.	A.M.—And P.M. with fine ſparks.
27	SE	30.45	30	—	Neg	At break of day. Afterwards poſitive, by means of a fog.
28	W	30.43	33	—	Poſ.	All day, by a continued fog.
29	NW	30.30	35	S	Poſ.	All day. The fog ſtill continues. I have obſerved, during theſe three days and three nights (abating a little time for ſleep, and which I curtailed for ſo noble a purpoſe) a foggy vapour to be conſtantly electrified poſitively. The pith balls diverged from a quarter to three quarters of an inch, except when the fog (which was generally moderate) ſuddenly became thick and dark; then the balls would diverge near two inches; at thoſe times I received the electric fluid into bottles. This fog began ſtrongly negative.
30	S	30.10	38	—	Poſ.	Nearly all day. The fog is entirely gone.
1	SE	29.71	38	—	——	Weak ſigns; balls not open.
2	S	29.75	50	—	Poſ.	P.M. A moiſt air to-day.
3	S	29.90	39	S	Poſ.	All day (I mean 16 hours out of 24), the weather foggy.
4	S	30.10	43	—	——	Weak ſigns; balls not open.
5	SW	30.38	52	—	——	
6	SW	30.40	48	—	——	No ſigns of electricity. The third failure. A very moiſt air.
7	SW	30.49	42	—	Poſ.	A.M.—A ſlight fog.
8	SW	30.54	40	S	Poſ.	P.M.
9	SW	30.55	34	—	Poſ.	A.M.
10	W	30.52	39	—	——	Weak ſigns; balls not open.
11	SW	30.54	42	—	Poſ.	A.M.—And P.M. The weather ſerene and fair.
12	SW	30.41	44	—	Poſ.	
13	SW	30.30	47	—	——	Weak ſigns.
14	S	20.92	44	—	Neg	A.M. from a little rain.
15	SW	28.95	45	—	——	No ſigns of electricity. The fourth day's failure.
16	SW	29.40	40	S	Poſ.	P.M. a ſmall fall of ſnow, by which the rod was ſtrongly electrified.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	December—And January 1790.
		Inch.	o			
17	W	29,15	38	—	——	No ſigns of electricity. The fifth day's failure.
18	W	30.	50	S.	Poſ.	A.M. a fine ſerene morning.
19	SW	29.58	44	—	Neg	P.M. by ſmall rain. On an increaſe of rain, the electricity changed to poſitive.
20	SW	29.72	44	—	——	Weak ſigns.
21	SW	29.78	45	—	——	No ſigns of electricity. The ſixth day's failure. A very damp air.
22	SW	29.60	56	—	——	No ſigns. The ſeventh day's failure. A moiſt air.
23	W	29.78	49	—	——	Weak ſigns of electricity.
24	W	29.27	52	S.	Neg	At eight o'clock, A.M. a ſmall ſhower of rain, which was weakly electrified negatively; as the rain increaſed, ſo did the intenſity of the electric fluid, and after continuing for two hours, they both diſappeared together.
25	SW	29,41	42	S.	Neg	A.M. by a ſhower of rain. Ten o'clock P.M. a fog ſtrongly electrified poſitively.
26	W	29.89	46	S.	Poſ.	A.M.
27	SW	29.80	46	—	——	Weak ſigns.
28	W	29.88	47	—	Poſ.	P.M. from a very thin fog.
29	SW	29.75	54	—	——	Only weak ſigns of electricity.
30	SW	29.76	42	—	——	
31	S	29.73	48	—	——	
1	SW	29.90	35	—	Poſ.	Both A.M. and P.M
2	S	30.30	36	S.	Poſ.	All day.
3	S	29.98	46	—	Poſ.	All the day, by means of a fog.
4	W	30.20	43	S.	Poſ.	All the day, with bright ſparks at ſeveral intervals.
5	N	30.25	45	S.	Poſ.	All the day, with fine ſparks.
6	SE	30.19	41	—	Poſ.	A.M.
7	W	30.40	41	S.	Poſ.	A.M. weather dry and foggy.
8	W	30.45	36	S.	Poſ.	Nearly all day in charge.
9	E	30.28	36	—	Poſ.	A.M. balls open near one inch.
10	SE	30.24	39	—	Poſ.	A.M.—And P.M.
11	S	30.11	41	—	Poſ.	P.M.
12	W	30.20	45	—	——	Weak ſigns.
13	SW	30.34	42	—	Poſ.	A.M.
14	S	29.95	49	S.	Neg	A.M. by means of a ſmall rain.
15	NW	29.91	43	—	Poſ.	A.M.
16	SW	29.95	42	S.	Poſ.	A.M. weather very mild and fair.
17	N	30.28	40	—	Poſ.	A.M.
18	NE	30.20	39	—	Poſ.	A.M. in the afternoon, the ſame.
19	E	30.13	33	—	Poſ.	A.M.
20	SE	30.24	32	S.	Poſ.	A.M.
21	E	30.40	31	S.	Poſ.	A.M. in the afternoon, the ſame.
22	W	30.38	35	S.	Poſ.	All the day, from a fog. The ſtrength of the electric charge in the rod was much governed by the occaſional intenſity of the fog; for as one abated in ſtrength ſo did

Days.	Wind.	Barom	Ther.	Sparks	Kind.	January and February.
		Inch.	°			the other, and the contrary. At ten o'clock P.M. I received bright ſparks at the ball N.
23	W	30.33	40	S.	Poſ.	Seven o'clock A.M. I found the rod electrified, ſufficiently ſtrong to emit viſible ſparks, and often afterwards this day.
24	W	30.16	46	S.	Poſ.	A. M.
25	NE	30.11	42	S.	Neg	There was a moderate ſhower of rain this morning, by which the rod was electrified negatively.
26	W	30. 2	40	—	Poſ.	A. M. balls open from two to ſeven tenths of an inch.
27	W	29.30	42	—	Poſ.	
28	S	29.50	44	S.	Poſ.	A. M.—At noon fell a ſmall rain, which was void of electricity. Near ten o'clock P. M. there was a ſudden ſhower of rain, ſtrongly electrified negatively.
29	W	29.26	40	—	Poſ.	P. M.—A delightful clear fine day, but the atmoſpheric electricity was very weak till night came on.
30	N	29.50	41	—	Poſ.	A. M.—and P. M. negative
31	S	29.68	46	—	Poſ.	Balls open from one to nine tenths of an inch, weather fair and ſerene.
1	N	29.87	40	—	Poſ.	
2	SW	30.10	40	—	Poſ.	
3	W	30.30	44	—	Poſ.	
4	W	30.60	46	—	Poſ.	
5	SW	30.61	43	—	Poſ.	
6	W	30.63	44	—	Poſ.	
7	NW	30.35	39	—	Poſ.	
8	N	30.22	36	—	Poſ.	
9	W	30. 5	40	S.	Poſ.	With viſible ſparks.
10	NE	30. 7	43	—	Poſ.	Serene weather ſtill continues.
11	W	30.20	41	—	Poſ.	
12	W	30.20	45	—	Poſ.	
13	SW	30.34	42	S.	Poſ.	Nearly all the day, with fine bright ſparks.
14	SW	30.15	44	—	Poſ.	Balls open from two to ſix tenths of an inch.
15	W	30.22	40	—	Poſ.	
16	S	29.95	44	—	Poſ.	A. M.—Small rain P. M. which did not occaſion any change in the electric fluid.
17	W	30.20	39	—	Poſ.	Balls open half an inch, weather ſtill ſerene.
18	W	30.42	42	—	Poſ.	
19	S	30.48	45	—	Poſ.	
20	SE	30.42	40	S.	Poſ.	A. M.—A foggy day.
21	SW	30.38	42	—	Poſ.	Balls open from one to nine tenths of an inch, weather ſtill mild.
22	SW	30.43	43	—	Poſ.	
23	S	29.97	46	—	Poſ.	
24	SW	30.15	44	—	Poſ.	
25	S	29.99	51	—	Poſ.	
26	W	29.88	51	—	Poſ.	P. M.—I have often obſerved that impetuous winds leſſen the intenſity of atmoſpheric electricity in clear weather, which

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	February and March.
		Inch.	°			has been verified this day; for not the leaſt ſign of electricity could be obtained from the rod till after ſun-ſet, at which time the high weſt wind having ſubſided, a little low vapour ſprung up; I then received the fluid in great plenty, and of the ſame kind that it has continued to be for twenty-ſeven days paſt.
27	W	30.20	42	—	——	Weak ſigns: balls not open.
28	NW	30.22	45	—	——	
1	N	30.32	47	—	Poſ.	A. M.
2	NW	30.49	50	S.	Poſ.	A. M.—With viſible ſparks.
3	N	30.33	49	—	Poſ.	Very mild ſerene weather.
4	NW	30.27	40	—	Poſ.	
5	NE	30.31	43	—	Poſ.	
6	NW	30.47	40	—	Poſ.	
7	NW	30.45	42	—	Poſ.	
8	SW	30.44	42	S.	Poſ.	A. M.—With viſible ſparks. Still no change of kind.
9	SW	39.20	41	—	Poſ.	A. M.
10	SW	29.90	46	—	Poſ.	P. M.—A ſtrong gale of wind has been predominant to day. The atmoſphere is extremely dry; the ſun appeared bright all day. No atmoſpheric electricity could be obtained till near ten o'clock at night. This day, at Hallifax, a fall of ſnow, accompanied with a flaſh of lightning and a clap of thunder.
11	SW	30.26	41	—	Poſ.	A. M.—Still moderate weather.
12	S	30.31	51	—	Poſ.	
13	SW	30.20	41	—	Poſ.	A. M.—From nine o'clock P. M. to eleven there was a moderate ſhower of rain, which was electrified negatively. I have not till this perceived a negative charge in the rod ſince January the 28th.
14	NW	30.50	49	—	Poſ.	A. M.—At Thurſo, in Scotland, hail, lightning, and thunder.
15	N	30.57	51	—	Poſ.	P. M.
16	N	30.60	40	S.	Poſ.	A. M.—With viſible ſparks.
17	NE	30.60	40	—	Poſ.	A. M.—A very dry atmoſphere.
18	NE	30.50	45	—	Poſ.	
19	E	30.55	44	—	Poſ.	
20	E	30.44	43	—	Poſ.	A. M.—There was an hoar froſt upon the graſs this morning.
21	E	30.39	44	—	Poſ.	A. M.
22	E	30.15	42	—	Poſ.	A. M.—Divergency of the pith balls from one to nine tenths of an inch.
23	SW	29.81	46	—	Poſ.	
24	S	29.80	51	—	Poſ.	
25	NW	30.	46	—	Poſ.	
26	E	30. 4	48	—	Poſ	

Days	Wind	Barom	Ther.	Sparks	Kind.	March and April.
		Inch.	°			
27	E	30.	46	—	Neg	A. M.—From a ſmall ſhower of rain. P. M. the electricity was poſitive.
28	NE	29.98	44	—	Poſ.	P. M.
29	N	30.	48	—	Poſ.	P. M.—The air a little foggy.
30	E	29.95	44	—	Poſ.	A. M.—Not a beam of ſun has appeared this day.
31	E	29.93	47	—	Poſ.	A. M.—Balls half an inch open.
1	E	30. 5	45	—	Poſ.	A. M.
2	E	30.20	41	S	Poſ.	A. M.—With viſible ſparks.
3	E	30.25	40	—	Poſ.	Balls open from one to ſeven tenths of an inch.
4	E	30.19	40	—	Poſ.	
5	NE	30.23	47	—	Poſ.	
6	E	29.95	36	—	Poſ.	
7	E	29.75	45	—	——	Weak ſigns of electricity. This very weak ſtate of atmoſpheric electricity has not happened ſince the 31ſt of December. There has been for many days a ſtrong eaſterly dry wind, which ſeems hitherto nearly void of the electric fluid.
8	E	29.75	52	—	——	
9	E	29.57	66	S.	Neg	P. M.—From a fine ſhower of rain.
10	E	29.50	40	S.	Neg	A. M.—The rain continues, ſo does its negative ſtate of electricity.
11	E	29.36	35	S.	Poſ.	A. M.—From a little fall of ſnow. P. M. ſome ſnow mixed with rain, on which the rod became charged much more ſtrongly poſitive. The rod has been charged full four hours to-day.
12	E	29.35	39	—	——	Weak ſigns; balls not open.
13	E	29.70	38	S.	Neg	A. M.—A moderate rain, but ſtrongly electrified, and continued ſo full two hours. There were two gradual changes of electricity.
14	NE	29.81	41	—	Neg	A. M.—But after ſun-ſet the rod was electrified poſitively.
15	E	29.68	35	S.	Neg	Six o'clock A. M. a little rain fell. Half after eight o'clock, a great fall of ſnow; the rod now became ſtrongly electrified poſitively. Denſe ſparks were now received at the ball N; half after nine o'clock, the electricity changed to negative. I caught ſome of the ſnow in the apparatus mentioned the 20th of July in this journal, and I found it weakly electrified.
16	NE	29.85	41	—	Poſ	Divergency of the pith balls were from a tenth to ſeven tenths of an inch. Fine ſerene weather.
17	N	29.98	42	—	Poſ.	
18	NE	29.80	40	—	Poſ.	
19	NE	29.69	41	—	Poſ.	
20	SE	30.26	45	—	Poſ.	
21	S	30.23	47	—	Poſ.	
22	S	29.94	51	—	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	April and May.
		Inch.	°			
23	SW	29.70	55	—	Poſ.	A. M.
24	W	29.55	52	—	Poſ.	A. M.—And P. M. negative from ſmall rain.
25	SW	29.60	51	S	Poſ.	Half paſt nine o'clock A. M. A diſtinct black cloud approached the rod, and ſome heavy drops of rain fell; the electricity of the rod then changed to negative. About half paſt three o'clock P. M. a very low cloud paſſed over the rod, and rained a little, by which the rod became ſtrongly electrified poſitively.
26	NE	29.85	53	S	Poſ.	A. M. Five o'clock P. M. fell ſome rain by which the rod was charged negatively.
27	N	29.98	47	—	Poſ.	The divergency of the balls from two to ſix tenths of an inch. Serene fine weather.
28	W	29.80	50	—	Poſ.	
29	SW	29.69	51	—	Poſ.	
30	S	29.58	53	—	Poſ.	
1	E	29.75	50	S	Poſ.	Nine o'clock A. M. a ſhower of rain; the electricity now became negative. The rod has been electrified to-day from ſix o'clock A. M. to ten o'clock P. M. and I ſuppoſe continued ſo all night.
2	N	30.22	41	—	Poſ.	Divergency of the pith balls from three to ſeven tenths of an inch.
3	NE	29.85	49	—	Poſ.	
4	SE	29.63	51	S	Poſ.	A. M.
5	S	29.73	52	S	Poſ.	Six o'clock, A. M. Eight o'clock it rained, the electricity now became ſtrongly negative, with fine ſparks at the ball N. This ſhower having ceaſed, another ſoon followed, which electrified the rod poſitively. The rod was charged 7 hours to-day.
6	SW	29.75	50	S	Neg	Every appearance at the rod to-day was nearly as during the preceding day.
7	W	30.10	56	—	Poſ.	Balls open from one to five-tenths of an inch. Such weak ſigns of electricity, as have been obſerved for theſe two days are the uſual effects of a very ſtrong and dry weſterly wind; and in general let a ſtrong dry wind blow from what point of the compaſs it may, it is attended with only weak ſigns of electricity.
8	W	29.84	50	—	Poſ.	

The above-mentioned eighth day of May completes this Journal of one whole year, which I give to the curious in Atmoſpheric Electricity as a faithful narrative of facts, having never once deputed another perſon to make obſervations for me. JOHN READ.

A Monthly Account of Electrical Sparks, and of Poſitive and Negative Electricity, as indicated by the Pith-ball Electrometer, and ſometimes by only Flaxen Threads without Balls to them.

		Times		Times	Number of days in each month in which Sparks were perceived. Days.
23 days May, 1789 8 days May, 1790	Poſ.	17	Neg.	18	9
June	Poſ.	32	Neg.	36	12
July	Poſ.	13	Neg.	22	12
Auguſt	Poſ.	19	Neg.	19	9
September	Poſ.	9	Neg.	23	7
October	Poſ.	17	Neg.	7	7
November	Poſ.	12	Neg.	8	8
December	Poſ.	12	Neg.	6	7
January	Poſ.	26	Neg.	4	13
February	Poſ.	26	Neg.	0	3
March	Poſ.	30	Neg.	1	3
April	Poſ.	28	Neg.	12	8
		241		156	98

It appears from this Journal, that there were only *ſeven* days throughout the year in which no ſigns of electricity were perceived; *viz.* the 15th and 23d of November, and the 6th, 15th, 17th, 21ſt, and 22d of December.

Remarks on the Phænomena exhibited by the Rod on the 31ſt of Auguſt.

I was for a long time extremely puzzled to account for the rapid changes which the pith-balls on ſome days ſo frequently exhibited; being poſitive one minute, then negative for another, and the next returning again to poſitive. From often conſidering this apparently whimſical changeableneſs in nature, I was at length induced to ſuſpect, what indeed was afterwards confirmed by actual experiment, *viz.* that ſome of theſe changes are only apparent, and not real, they being occaſioned not by the actual communication of a different ſort of electricity, but merely by the action of electrical atmoſpheres; thus, when an electrified cloud comes within a certain diſtance of the rod, and before it comes near enough to impart to it ſome of its own electricity, the electrical atmoſphere of the former, agreeably to the well known laws of electricity, will diſturb the electric fluid naturally belonging to the rod, and will conſequently occaſion ſeveral apparent changes in the electrometer; which changes an unexperienced obſerver would attribute entirely to the change of electricity in the clouds.

This obſervation was evidently confirmed by the phænomena obſerved on the 31ſt of Auguſt; and thence it appears, that the real number of changes from poſitive to negative, or from negative to poſitive electricity, cannot be ſo great as it is ſhewn by the electrometer affixed to the rod.

I beg leave to add, that I have not the leaſt doubt but that every cloud is in an electric ſtate, at all times, and in all the ſeaſons of a year; and that the electricity of the clouds is the principal cauſe of their ſuſpenſion in the atmoſphere. For however varied in kind their corpuſcles may happen to be, of which the clouds conſiſt, yet, every particle of thoſe aerial meteors will attract and abſorb electricity, and the electricity having no weight of its own, muſt by its well known repulſive force tend to ſupport and keep up their rare ſtate. When a cloud approaches my high pointed rod, which cloud we will ſuppoſe is electrified poſitively, the upper end of the rod will become electrified negatively and the lower end poſitively, by its own electricity, as before obſerved; and when the main force of the cloud has paſſed the zenith, a change of kind will take place, for the electric ſigns in the rod will now be the reverſe of thoſe on its approach to it; ſo that if ten ſuch clouds ſhould paſs over the rod in the ſpace of one day, the pith-balls affixed to it would indicate ten changes of the electricity, notwithſtanding the electric ſtate of the ten clouds was invariably of one kind. It is ſcarcely needful to obſerve, that if the ten clouds had been electrified negatively, the ſame number of apparent changes would have happened.

I cannot help lamenting with Signor Beccaria, that there are ſo few high pointed rods erected to aſcertain the electrical ſtate of the earth and atmoſphere at all times; but more particularly during thunder ſtorms. If there had been pointed rods, for inſtance, at Whitehaven and Lancaſter on the 6th of October, and well attended to at the time of the ſtorm of lightning and thunder, which happened at both places nearly at the ſame time, it would then have been known, whether the apparatus might not be poſitive at one place when it is negative at the other.

The Second Year's Journal, continued from the end of the Firſt. Read before the Royal Society, April 26, 1792.

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	May, 1790.
		Inch.	°			
9	N	29.14	67	S.	Poſ.	A clear fine morning. One o'clock P.M. a ſudden ſhower of rain fell; the pith balls O, connected with the lower end of the rod, were now charged negatively, and increaſed in ſtrength as the rain came on; in a ſhort time the electricity changed to poſitive. Five o'clock, the electricity changed again to negative, I then heard ſome diſtant rumbling of thunder. This day there was ſome lightning at Hertford.
10	NE	29.18	66	—	Neg	A. M. ſky very cloudy, and ſome ſmall rain falls.
11	E	30. 5	64	—	Poſ.	Strong gales of wind; and a weak electricity.
12	E	29.14	70	—	Poſ.	
13	E	29. 6	72	—	Poſ.	
14	NE	30. 9	72	—	Poſ.	
15	N	29. 5	65	—	Poſ.	A. M. weather ſerene.
16	NE	29. 2	57	—	Poſ.	A. M. a clear ſky. Some lightning at Biſhop-Stortford.
17	S	29. 8	58	S.	Poſ.	Half after nine o'clock A. M. fell a little rain; as it increaſed ſo did the electric charge in the rod, inſomuch that it ſtreamed forth from the braſs ball N for a ſhort time.
18	SW	29.90	59	S.	Poſ.	Six o'clock A. M.—One o'clock P. M. a low black ſky, by which the charge in the rod became negative, with ſparks; after continuing ſo one hour, the electricity changed again to poſitive. The rod has been in charge 16 hours this day; how much more I cannot ſay.
19	S	29.20	65	S.	Neg	A. M.—At four o'clock P. M. fell a mild rain, void of the electric fluid*. At five o'clock the rain fell more copiouſly, and it was ſtrongly charged with negative electricity.
20	S	29.14	64	S.	Neg	Early this morning I found the humidity of the air electrified negatively. At ten o'clock the electricity became more intenſe, ſo as

---

*My meaning is "void" of electric ſigns by ſuch means as were then employed to obtain it; for rain is never totally void of electricity.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	May.
		Inch.	°			
						to emit ſmall ſparks: in half an hour's time there were four beautiful gradual changes of electricity. Afterwards the rod remained negative two hours. Three o'clock P. M. the electricity changed, and continued near three hours poſitive. After this a low black cloud paſſed over the rod, and let fall a few drops of rain mixed with hail; the rod was now highly charged poſitively, and the bell rang briſkly, but ſoon ſtopped, while the electricity changed to a ſtrong negative; then it rang again for about ten minutes, after which all ſigns of electricity ceaſed in the rod. Afterwards the rod became rather ſtrongly charged for the ſpace of two hours, and changed once in that time. During this high charge of the rod, the bell, (which is connected by metal with the moiſt ground) was in a contrary ſtate of electricity to that of the inſulated part of the apparatus; and alſo the air in the room, the window-ſhutter neareſt the bell, and even the bricks in the wall, were all electrified ſufficiently to indicate the kind.
21	SW	29.98	58	S	Poſ.	A. M. by the night bottle, which had been charged while I ſlept. Four o'clock P. M. a low cloud approached the rod, and dropped a little rain, by which it became electrified ſtrongly negative. This electrification of the rod laſted near four hours, and changed three times in kind.
22	E	29.10	56	—	Poſ.	A. M.—One o'clock P. M. wind S, a ſmall rain fell, and the air being very moiſt, has leſſened conſiderably the inſulation of the rod.
23	S	29.90	56	—	Poſ.	The air is dry to-day, but the clouds are very high.
24	NE	29.10	69	S	Neg	Six o'clock A. M. Nine o'clock ſome rain fell, which increaſed the negative charge in the rod. The rain now falls more copiouſly, and the balls cloſe and open gradually with poſitive electricity, which was rather ſtrong for a ſhort time. The balls again gradually cloſe and open, without change of kind. The rod has been electrified near 14 hours this day. In the morning of to-day, at Lewes in Suſſex, much lightning and thunder.
25	NE	29. 4	70	—	Neg	A. M. A moiſt air, and wet morning.
26	E	29.95	62	S	Poſ.	A dark cloudy morning. Three o'clock P. M. on the approach of a heavy dark

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	May and June.
		Inch.	°			
						cloud, a few drops of rain fell, by which the rod became electrified poſitively; the pith balls ſoon opened full four inches, and by and by the bell began to ring ſlowly. Two gentlemen fortunately being preſent, and much delighted with the ſight, by my deſire joined hands with me to make the circuit between the bell and braſs ball N, and on taking a ſpark at the braſs ball, we all received a ſmart ſhock through our arms and breaſts. The wind is now S. with a heavy fall of rain; and the bell (as uſual) ceaſes to ring while the electricity changed to negative; then rings again briſkly. The electricity gradually changed twice after this, and ended negative. Theſe ſeveral phænomena took up the ſpace of one hour.
27	N	29.98	69	—	Neg	A. M. with ſmall rain. In the afternoon poſitive. Near midnight London was viſited by vivid darts of lightning, and repeated claps of thunder, extremely awful and terrific at that time of night. I was in bed, and awaked out of ſleep by it.
28	NE	30.	61	S.	Neg	By the night bottle. A heavy thick air. Seven o'clock P. M. poſitive with ſmall ſparks. Nine o'clock, fell a heavy ſhower of rain; its electricity was negative.
29	SE	30.	69	—	Poſ.	A. M.—and P. M.
30	SW	30· 6	63	S.	Poſ.	At ſeven o'clock A. M. the weather ſhowery and the electricity rather ſtrong, but often changing in kind. Seven o'clock P. M. one uniform black cloud darkens the air (yet the ſun ſhines in the weſt;) by and by a heavy rain fell, by which the rod became very ſtrongly electrified poſitively, and the bell rings briſkly, and the pith balls are agitated with ſudden jerks; the rain ſoon abated, and its electricity became negative. Theſe operations of nature laſted only 34 minutes; during that time, the electricity was four times poſitive, and five times negative; and theſe ſeveral changes were all gradual.
31	N	30.	58	S.	Neg	The weather, and the electricity of the atmoſphere have been this day nearly the ſame as on the preceding one.
1	S	30.12	58	—	Poſ.	Serene fine weather, theſe five days.
2	N	30.16	69	—	Poſ.	
3	SW	30.12	66	—	Poſ.	
4	N	30. 8	61	—	Poſ.	
5	N	30.18	58	—	Poſ.	

Days	Wind	Barom	Ther.	Sparks	Kind.	June.
		Inch.	°			
6	N	30.16	62	—	Poſ.	A. M. Two o'clock P. M. the ſky ſtill clear; yet the electricity of the rod became negative, and continued ſo two hours. During this time, the rod was only electrified with its own electricity, or what has been termed influentially electrified; for I found by trying both extremities of the rod, that they were in contrary ſtates of electricity.
7	W	30.	62	—	Poſ.	A. M. A warm moiſt air.
8	SW	29.91	66	—	Poſ.	A. M. Some mizzling rain.
9	S	29.65	64	—	Poſ.	A. M.
10	SW	26.60	65	S.	Poſ.	A cloudy morning. Half after one o'clock P. M. the electric charge in the rod became negative. In a ſhort time after, ſome rain fell, and the electricity again became poſitive, and very ſtrong; the bell now rang ſlowly, and ſoon ſtopped; the pith balls cloſed and opened negative, and continued ſo a full hour: the balls exhibited one ſudden jerk during that time. This latter charge of the rod laſted two hours. During the paſſage of a cloud over the rod, in the morning of to-day, I found it influentially electrified.
11	N	29·90	65	—	Poſ.	The weather ſerene and clear. The electricity varying between null and the balls ſeven-tenths of an inch open.
12	N	30·1	59	—	Poſ.	
13	NE	30·29	60	—	Poſ.	
14	NE	30·30	64	—	Poſ.	
15	NE	30·30	69	—	Poſ.	
16	N	30·23	54	—	Poſ.	
17	E	30·10	61	S.	Neg	After a courſe of clear ſerene weather, this day has been dark, and hazy. Nine o'clock P. M. wind S, a prodigious large cloud approached the rod, and a little rain fell, yet there were no ſigns of electricity in the rod. In a few minutes after this, I was ſurpriſed by hearing the bell ring; I ran to the apparatus, and found it highly charged negatively. When the main bulk of the cloud arrived over the rod, its electricity changed to a ſtrong poſitive; and in a quarter of an hour, the rain and electricity all ceaſed together. This day, in the evening, at Wolverhampton, fell a heavy rain, accompanied with lightning and thunder.
18	NW	29.91	63	—	Poſ.	A. M.—and P. M.
19	S	30.	68	—	Neg	A dark cloudy morning. The electricity poſitive at five o'clock P. M.
20	SW	30.21	74	—	Poſ	Weather very hot, and a weak electricity, theſe two days.
21	SW	30.35	76	—	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June.
		Inch.	°			
22	E	30.29	79	—	Poſ.	A. M. Serene hot weather. Near ſun-ſet the wind W, where heavy black clouds were forming, their upper border about 25 degrees above the horizon. The lightning flaſhed among theſe weſtern clouds from nine to eleven o'clock. But there being neither clouds nor low vapour near the rod, it was not affected thereby. In the evening of this day at Saliſbury, fell a very ſevere ſtorm of hail, rain, lightning, and thunder.
23	SW	30.	78	—	Poſ.	A. M.
24	W	30.	68	—	Poſ.	A. M.—The ſky has been overcaſt all day, and two or three times fell a little rain, driven by a ſtrong wind, which afforded a weak electricity.
25	W	29.90	68	S.	Poſ.	At ſix o'clock A. M. Near eleven o'clock a ſhower of rain fell, ſtrongly negative. At the ſame time, in a LOWER STRATUM of air, the hand exploring rod was electrified POSITIVELY. Abundance of ſmall white clouds paſſed over the rod, which kept the pith balls continually cloſing and opening, with negative electricity. Eight o'clock P. M. ſome heavy drops of rain fell; the rod now became very ſtrongly electrified; the bell rang ſlowly, and ſoon ſtopped, while the electricity changed to a ſtrong poſitive, then rang again more briſkly and for a longer time. After this there were two more gradual changes of electricity.
26	NW	29.90	63	S.	Poſ.	The weather, and atmoſpheric electricity, have been this day nearly the ſame as on the preceding one; only the operations in the rod have been more powerful. For during one charge of the rod to-day, I counted about forty denſe ſparks, which ſpontaneouſly ſtruck between the bell and braſs ball N in quick ſucceſſion. Theſe ſparks were about two inches long.
27	N	29.96	61	S.	Poſ.	A. M. Four o'clock P. M. I ſaw heavy clouds forming; and as they came nearer and nearer, the rod became more powerfully electrified with negative electricity. It now began to rain, by which the rod became intenſely electrified indeed; many denſe ſparks now ſtruck through the air, between the bell and braſs ball N, with a loud report for ſo ſmall an opening of two inches only. There were ſix changes of electricity in two hours.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June and July.
		Inch.	°			
28	W	30. 5	57	—	Poſ.	Mild foggy weather; and the fog moderately electrified.
29	N	30.	70	—	Poſ.	
30	SW	30.	67	—	Poſ.	
1	W	29.83	66	S.	Poſ.	A. M.—Negative P. M. with ſmall ſparks.
2	W	29.77	63	S.	Poſ.	A. M. Half after twelve o'clock P. M. a ſudden guſt of wind ſprung up, followed by a ſhower of rain, which electrified the rod poſitively, ſufficient to emit ſmall ſparks; which ſoon afterwards became negative. Near four o'clock P. M. a very large black cloud paſſed over the rod, and let fall a little rain mixed with hail, by which the rod became highly electrified negatively: the bell now rang briſkly, untill a flaſh of lightning and inſtant crack of thunder happened, which occaſioned a ſudden change in the electricity to poſitive: then the bell ſtruck up again as briſk as before. The rod has been charged ten hours without intermiſſion this day.
3	NW	29.72	70	—	Poſ.	A. M. A cloudy atmoſphere, but fair.
4	SW	29.66	69	—	Poſ.	A. M. Dull heavy weather.
5	SW	29.40	64	S.	Neg	This day has been ſhowery and ſunſhine by turns. The rod has been rather ſtrongly electrified, and there have been four gradual changes of electricity. One charge laſted full five hours, and the bell rang briſkly.
6	N	29.70	65	—	Neg	Strong gales of wind with rain, and a weak electricity theſe two days.
7	N	30.10	63	—	Neg	
8	SW	30.	63	—	Poſ.	A. M.
9	SW	29.86	67	—	Neg	A. M. A thick moiſt air.
10	SW	29.90	61	S.	Poſ.	A. M. Near five o'clock P. M. there was a fine ſhower of rain, by which the rod firſt became electrified negatively, and afterwards poſitively, with ſparks. Theſe two charges laſted five hours.
11	NW	29.60	61	S.	Neg	Half after ten o'clock A. M. large dark clouds frequently paſſed over the rod, by which it became electrified negatively. When they paſſed ſomewhat nearer, and diſmiſſed ſome large drops of rain, the rod then became highly charged, and the bell rang briſkly, and continued its ringing near half an hour. The pith balls were very much agitated, ſometimes with a pendulous motion, then ſtarted cloſer or wider aſunder ſeveral times. But the moſt extraordinary phænomenon of to-day is, that the rod continued ten hours electrified negatively, with-

Days.	Wind.	Barom. Inch.	Ther. °	Sparks	Kind.	July and Auguſt.
						out change of kind: during that time the pith balls never cloſed.
12	N	29.70	63	S.	Neg	The operations in the rod to-day and yeſterday, when compared, appear to have but little reſemblance. This day the electricity has changed four times, and the bell rang briſkly for a minute or two between each change of electricity.
13	W	29.62	64	S	Poſ.	Two o'clock P. M. the wind S. A ſudden ſhower of rain fell, by which the rod became electrified poſitively, but ſoon changed to negative. The bell now rang weakly one minute, and then ſtopped while the electricity changed to poſitive, which ſoon changed again to negative. The electricity and the weather have been much varied to-day. At New-Mills, in Scotland, ſome lightning and thunder.
14	NW	29.57	57	S.	Neg	The weather this day has been rather more varied than yeſterday, with a continued ſucceſſion of ſhowers and ſunſhine: and the atmoſpheric electricity has been conſiderably more intenſe, and conſtant. There have been five gradual changes of electricity; between four of thoſe changes, the bell rang briſkly. The pith balls alſo exhibited ſome of their curious agitations; one jerk in particular was ſo very quick and powerful, that the balls were near ſtriking each other. In a few minutes after this, I heard diſtant thunder. At Burwaſh, in Suſſex, this day a tempeſt of rain, lightning, and thunder.
15	NW	29.78	60	—	Poſ.	The weather theſe 19 days has been generally moderate; and the electricity of the atmoſphere has been only what is common for ſerene weather, at no time ſufficiently ſtrong to afford viſible ſparks.
16	NW	29.95	63	—	Poſ.	
17	SW	30.13	69	—	Poſ.	
18	W	30.10	66	—	Poſ.	
19	SW	30. 5	65	—	Poſ.	
20	SW	29.75	66	—	Poſ.	
21	W	29.78	63	—	Poſ.	
22	NW	30. 5	61	—	Poſ.	
23	SW	30.	64	—	Poſ.	
24	W	30.	66	—	Poſ.	
25	SW	30.12	69	—	Poſ.	
26	SW	30.15	66	—	Poſ.	
27	W	30.11	67	—	Poſ.	
28	S	30.10	63	—	Poſ.	
29	N	29.65	57	—	Poſ.	
30	NW	29.65	60	—	Poſ.	
31	SW	29.55	63	—	Poſ.	
1	NW	29.92	59	—	Poſ.	
2	SW	29.95	61	S.	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	Auguſt.
		Inch.	°			
3	SW	297 7	63	S	Poſ.	A heavy cloudy morning, but fair. Half after one o'clock A. M. a ſmart ſhower of rain fell, by which the rod became highly charged with negative electricity; when the cloud was fully over the rod, the electricity changed to poſitive; and when it had paſſed the zenith, the electricity changed again to negative.
4	NW	29.83	62	—	Poſ.	Serene weather, and a weak electricity, theſe four days.
5	SW	30.	67	—	Poſ.	
6	SW	29.93	67	—	Poſ.	
7	SW	30.	72	—	Poſ.	
8	W	29.92	67	—	Poſ.	A heavy cloudy morning, but fair. The electricity of the atmoſphere has been ſo weak to-day, that none could be obtained till after ſun-ſet.
9	W	30.	63	—	Poſ.	A. M.
10	SW	30. 5	63	—	Poſ.	Serene weather: the pith balls varying between null and three-quarters of an inch open.
11	W	30.10	66	—	Poſ.	
12	SW	30.10	72	—	Poſ.	
13	SW	30. 5	69	—	Poſ.	
14	N	30.10	64	—	Poſ.	
15	S	30. 3	72	—	Poſ.	
16	S W	29.90	73	—	Poſ.	There have been ſeveral ſmall ſhowers of rain this day, ſome of them not ſenſibly electrified, others were weakly poſitive, but which I could not diſtinguiſh from the common electricity of ſerene weather, which has prevailed a long time.
17	W	30.	66	—	Poſ.	Serene weather; divergency of the pith balls from one to ſeven-tenths of an inch.
18	N	30.10	66	—	Poſ.	
19	SW	30. 1	66	—	Poſ.	
20	NW	30. 4	76	—	Poſ.	
21	S	29.75	77	S	Poſ.	A. M. Five o'clock P. M. fell ſome large drops of rain, by which the rod was highly charged poſitively; the bell rang briſkly about five minutes, then ſtopped, and the electricity of the rod became negative. The rain now ceaſed, the ſky cleared up and the electric charge in the rod decreaſed conſiderably, and ended as it begun, poſitive.
22	W	34. 4	62	—	Poſ.	Dark cloudy weather, and a very moiſt air, attended with a weak electricity.
23	SW	29.95	67	—	Neg	
24	W	30.	63	—	Poſ.	
25	SW	29.36	62	—	Poſ.	
26	N	22.70	64	—	Poſ.	
27	N	29.83	62	S	Poſ.	This day has been very ſhowery, yet only one ſhower was ſtrongly electrified.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	Auguſt and Sept. 1790.
		Inch.	°	—	—	
28	W	29.95	59	—	Poſ.	Serene weather, and a conſtant electricity theſe five days.
29	NW	30.	60	—	Poſ.	
30	W	30.12	62	—	Poſ.	
31	SW	30.10	66	—	Poſ.	
1	W	29.95	67	—	Poſ.	
2	SW	29.80	62	S.	Poſ.	A. M. In the afternoon, there was a thick dark ſky, with ſmall rain, and a ſtrong wind. On an increaſe of rain, the electricity became negative, with ſmall ſparks. When the rain abated, the electricity changed to poſitive, and continued ſo.
3	W	29.50	58	S.	Poſ.	A. M. Near one o'clock P. M. the electric charge in the rod was negative. I then ſaw thunder-clouds forming in the ſouth, and in the north. Some large drops of rain now fell, by which the charge in the rod became very ſtrong; the bell now rings faintly, and the pith balls exhibit their waving motion, and ſometimes ſudden jerks. The diſtinct thunder-cloud, which was in the north, is now gone by the weſt into the ſouth, during which the charge in the rod became weaker and weaker, until it ended as it began, negative. This electric charge of the rod continued near one hour and a half.
4	W	29.65	58	S.	Poſ.	A. M. One o'clock. P. M. wind NW. Thin white clouds have been paſſing over the rod; but a diſtinct black one is now approaching, and ſome rain falls, mixed with hail; the rod is now highly charged with poſitive electricity; the bell rings loud, and a long time; and, as the ſhower abated, ſo did the ſtrength of the electric charge abate in the rod. This charge laſted near three hours, without change of kind.
5	NW	29.70	55	S.	Poſ.	A quarter before three o'clock P. M. ſome rain fell, by which the rod became moderately charged poſitively, but ſoon changed to a weaker negative. There were two more gradual changes of electricity within the ſpace of one hour.
6	N	30.	58	S.	Neg	Three o'clock P. M. a large dark cloud paſſed over the rod with drizzling rain; its electricity was negative; the bell rang weakly. The electric charge from this cloud began, continued, and ended, negative.
7	N	30.10	51	S.	Poſ.	A. M. by the night bottle. Two o'clock P. M. a dark cloud, with drizzling rain,

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	September.
		Inch.	°			
						paſſed over the rod, by which it was electrified poſitively, with ſparks; and ended negative.
8	N	30. 5	57	—	Poſ.	Moderate fine weather, and a weak electricity, theſe ſeven days.
9	SW	30. 8	62	—	Poſ.	
10	NW	30.	58	—	Poſ.	
11	SW	30. 1	51	—	Poſ.	
12	SW	30.10	62	—	Poſ.	
13	W	30.	61	—	Poſ.	
14	S	29.84	62	—	Poſ.	
15	SW	29.80	66	S.	Poſ.	The rod has been electrified poſitively nearly all this day. At five o'clock P. M. an awful darkneſs covered the heavens, until near ſix o'clock, ſucceeded by a drizzling rain, from which I could not obtain (in my common way) any electric fluid: but when the dark cloud became broken, and no rain fell, I then obtained viſible ſparks at the ball N, which continued until I went to bed; and ſeemed to indicate that it would remain ſo all night, as the night was perfectly ſerene, and clear moonlight.
16	W	30.	55	S.	Poſ.	Five o'clock this morning, I found the rod charged poſitive, but not quite ſo ſtrong as when I left it laſt night; and it gradually went off by nine o'clock, and returned again into the rod at near four o'clock P. M. from which time the electric fluid gradually increaſed with the cool of the evening, until viſible ſparks appeared at the braſs ball N. In this ſtate of intenſity I left it at near eleven o'clock.
17	W	30.28	59	S.	Poſ.	This morning, a little after five o'clock, I found the rod rather ſtronger charged with the ſame kind of electricity than when I left it laſt night; and I have no doubt but it has been electrified all night. The pith balls have never cloſed this day: their divergency has been between half an inch and two inches open. Weather ſerene.
18	SW	30.10	54	S.	Poſ.	Five o'clock A. M. I found the rod electrified poſitively, and nearly of the ſame intenſity it was in when I left it laſt night; that is to ſay, capable of emitting ſmall ſparks. The atmoſphere this morning is perfectly ſerene. There is a dew, or low fog, about five or ſix feet high, ſpread over the ground in Hyde-park, very beautiful to look upon from an upper window. For the ſpace of two hours, this vapour gradually increaſed, and aſ-

Days.	Wind.	Barom	Ther.	Sparks	Kind.	September.
		Inch.	°			
						cended higher and higher, until it quite intercepted the trees from my ſight, and became a pale wet fog; which very much injured the inſulation of the rod: for during its increaſe in height, the electricity of the rod decreaſed, inſomuch, that I had almoſt concluded that the pith balls touched each other. But during this ſhort ſuſpenſe the ſun roſe higher, and diminiſhed the fog very faſt; and the electricity in the rod ſoon increaſed to its former ſtrength; and ſo continued all day.
19	S	29.85	63	S.	Poſ.	Five o'clock, A. M. I found the rod electrified poſitively, but rather weaker than when I left it laſt night. The weather this day has been nearly the ſame with that of the preceding one; only the fog began later, and continued longer. The rod has been electrified all this day.
20	W	29.70	57	S.	Poſ.	Near ſix o'clock, A. M. I found the rod electrified, but very weak, barely ſufficient to indicate the kind, and it remained ſo till near three o'clock P. M. The pith balls now cloſed (which I ſuppoſe has not happened before during the ſpace of 92 hours) and opened negative. A heavy cloud from the NNW now approaches the rod, and a little rain falls, by which the rod is highly electrified negatively, and the bell rings briſkly; the pith balls diverge to their utmoſt limit, and exhibit their waving pendulous motion; theſe operations took up about one hour. The rod continued electrified negatively in a leſs degree the reſt of the day.
21	NW	29.90	58	—	Neg	By the night bottle. The electricity in the rod barely ſenſible.
22	W	30.20	52	S.	Poſ.	The pith balls have not cloſed this day. The weather ſerene.
23	S	29.95	52	S.	Poſ.	This morning, a quarter before ſix o'clock, I found the electric charge in the rod much weaker than when I left it laſt night; which I afterwards found had been occaſioned by a ſpider fixing its web from the rod to the wall of the houſe; for when the web was removed, the intenſity of the electrical charge was ſoon increaſed.
24	N	30.30	58	—	Poſ.	Dark cloudy weather, and a ſtrong wind theſe two days.
25	NW	30.30	58	—	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	September and Oↄtober.
		Inch.				
26	NW	30.38	55	S.	Poſ.	Between ſix and ſeven o'clock this morning, I found the pith balls quite cloſed; nor would they even ſtick to my finger when I touched them. At this inſtant there was a viſible dewy vapour ſpread over the ground in Hyde-park: I examined it with my hand exploring rod, and quickly charged an electrometer ſufficient to aſcertain the kind, which was poſitive. I now ſuſpected my daily enemies the ſpiders; I therefore went upon the roof of the houſe with my long broom in my hand, and gently ſwept the rod down; on examining the broom, I found a ſpider's web entangled in the feathers. I then went down to the apparatus, and found the pith balls a quarter of an inch open poſitive, which gradually increaſed, even to viſible ſparks.
27	SW	30.35	57	S.	Poſ.	Six o'clock, A. M. I found the electric charge in the rod much weaker than when I left it laſt night. Nevertheleſs, when the ſun got up a little above the horizon, the rod became ſtronger electrified. The pith balls never cloſed this day.
28	SE	30.12	48	S.	Poſ.	The operations of the rod to-day have been nearly the ſame with the preceding one.
29	N	30.12	55	S.	Poſ.	This morning, a little before ſix o'clock, I found the pith balls cloſed. Atmoſpheric electricity has been more variable during a large part of this day than for many; ſometimes quite null, then weak, or ſtrong by turns, until three o'clock P. M. when it again became conſtant during the remainder of the day.
30	NE	30.25	58	S.	Poſ.	Six o'clock, A. M. I found the pith balls open full three quarters of an inch poſitive, and they continued open all day. Their leaſt divergency (as uſual) about mid-day. The weather ſtill thick and dark in the forenoon; and clear ſerene weather in the afternoon.
1	E	30. 5	52	S.	Poſ.	Six o'clock, A. M. I found the pith balls opened near one inch and a quarter; and they never cloſed this day. Their leaſt divergency, as uſual, was about mid-day, and their greateſt was near midnight. Weather ſerene.
2	E	29.84	56	S.	Poſ.	Six o'clock, A. M. I found the pith balls nearly cloſed, and the ſtate of the air moiſt and foggy. Half after ſeven o'clock, the

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October.
		Inch.	°			
						balls opened a little wider, and continued to increaſe in ſtrength, ſo that between eleven and twelve o'clock, their divergency was full three inches. I ſaw nothing in particular to occaſion it; and I thought it was above the intenſity of common ſerene weather. I ſaw indeed a dark cloud, but it was at a very great height. However, this electric charge continued in the rod until ſeven o'clock P. M. when a ſhower of rain fell, and the pith balls now cloſed, and opened negative: a fact that had not happened for eight days. After the rain had ceaſed, the electricity again became poſitive.
3	SE	29.80	63	—	Poſ.	A wet morning, the air moiſt, and a weak electricity.
4	NE	29.90	56	S.	Poſ.	A very moiſt air. Half after ten o'clock, fell a very heavy rain, which continued three hours. Its electricity was poſitive, but not ſtrong.
5	SW	30. 2	58	S.	Poſ.	A foggy damp morning. The rod has been electrified nearly all day.
6	S	29.85	60	S.	Neg	A heavy cloudy morning. Two o'clock P. M. the clouds float in the air lower than in the morning; and the rod is electrified negatively. Four o'clock, a heavy black cloud paſſed the rod, by which it was ſtrongly electrified, but ſtill negative, and continued ſo a full hour. During this time there were ſeveral ſudden jerks exhibited by the pith balls. Near ſun-ſet, the balls cloſed, and opened poſitive, and remained ſo. In the eaſt part of Kent, ſome lightning and thunder this day.
7	S	29.85	61	—	Poſ.	A. M. the weather mild and fair.
8	N	29.85	54	S.	Neg	By the night bottle:—by the rod poſitive.
9	N	29.90	52	—	Poſ.	A. M. Perfectly fine weather.
10	W	30. 4	42	—	Poſ.	The electricity conſtant this day.
11	SW	30. 8	39	S.	Poſ.	The rod electrified all this day.
12	SW	29.86	56	S.	Poſ.	A little after ſix o'clock, A. M. I found the rod electrified, but rather weaker than when I left it laſt night. The weather cloudy, with a thick moiſt air. One o'clock P. M. fell a ſudden ſhower of rain; the electricity now changed to negative, with ſmall ſparks.
13	W	29.75	50	S.	Poſ.	A little after ſix o'clock A. M. I found the rod electrified poſitively. A warm mizzling rain and moiſt air. Ten o'clock P. M. balls open two inches.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October.
		Inch.	°			
14	W	29.80	61	—	Poſ.	Six o'clock A. M. balls open half an inch poſitive.
15	W	30.	59	S.	Poſ.	A. M. Fair weather, and ſtrong gales of wind.
16	W	30.34	43	S.	Poſ.	Six o'clock A. M. balls three-tenths of an inch open. The pith balls have not been unelectrified this day.
17	S	30.15	55	S.	Poſ.	During a continuance of moderate weather, I have frequently obſerved that the atmoſpherical electricity has periods of increaſe and decreaſe of quantity, which are tolerably regular; I ſhall therefore be accurate in my account of this day's variation, as it may ſerve for an example of reference to many other days when ſimilar appearances took place. When I left the rod laſt night, the pith balls were one inch open, poſitive. Six o'clock this morning, I found them three-tenths of an inch open, poſitive, and ſoon after this I perceived them to open wider and wider, ſo that a little before nine o'clock, the pith balls were ſtationary at near two inches open. But as the ſun advanced towards the meridian, the electric charge in the rod decreaſed; and it was only poſſeſſed of various degrees of a weak intenſity until four o'clock P. M.: the pith balls were then only two-tenths of an inch open. Half an hour after four o'clock, they began to increaſe their divergency, which gradually held on till a little after ſeven o'clock, when they again became ſtationary at full two inches open; a little after eight o'clock, they began to decreaſe; nine o'clock, they were one inch and a quarter open; near eleven o'clock, I left them at a bare inch open.
18	SW	29.90	62	S.	Poſ.	Six o'clock, pith balls two-tenths of an inch open, poſitive. A dark cloudy morning. One o'clock P. M. ſome rain fell, yet the electric charge in the rod was poſitive. Near three o'clock, the fall of rain ſuddenly increaſed, ſo did the electric charge in the rod; and at the ſame time changed to negative, with ſparks; and after this ended poſitive.
19	W	30.15	39	S.	Poſ.	The rod has not been unelectrified this day: and the facts and appearances have been nearly like thoſe of the 17th inſtant.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October and November.
		Inch.	°			
20	E	30. 5	46	S.	Poſ,	The operations of the electricity in the rod to-day have been nearly the ſame with thoſe of the 17th inſtant.
21	SE	29.91	62	S,	Poſ.	The electric charge in the rod has been conſtant this day; and for particulars may juſtly be referred to the 17th inſtant.
22	SE	29.78	59	S.	Poſ.	A. M. The pith balls cloſed and opened, without change of kind, ſeveral times this day: and they have been very irregular when compared with many of the preceding. A thin wet fog has prevailed all this day.
23	SE	29.75	53	S.	Poſ.	A. M. Four o'clock P. M. fell a mizzling warm rain, by which the rod became electrified negatively, and emitted ſmall ſparks. When the rain was over, the rod was electrified poſitively, and it continued ſo.
24	NE	29.76	54	S.	Poſ.	The rod has been conſtantly electrified this day, and has been ſtrictly periodical. See 17th inſtant.
25	N	29.75	54	S.	Poſ.	The ſame as the preceding day.
26	N	29.89	50	S.	Poſ.	The operations of the electric fluid in the rod this day have been nearly ſimilar to thoſe of the 17th inſtant.
27	E	29.90	49	—	Poſ.	Dark moiſt air, but fair, and ſome briſk gales of wind, theſe four days.
28	NE	29.73	49	—	Poſ.	
29	NE	29.80	47	—	Poſ.	
30	NE	29.85	44	—	Poſ.	
31	N	29.88	42	S.	Poſ.	The thick eaſterly wind is now over-ruled by a clear northerly one; and the electrification of the rod this day has been of the periodical kind. The pith balls never cloſed.
1	S	29.80	46	S.	Poſ,	Near ſix o'clock A. M. I found the pith balls open one inch and a quarter, poſitive; which is rather leſs than when I left them laſt night. Half an hour after ten o'clock, fell a heavy ſhower of rain: the pith balls now cloſed, and ſoon opened negative, which, with the rain, continued the reſt of the day.
2	SW	29.45	49	—	Poſ.	P. M. fair weather.
3	SW	29.80	44	S.	Poſ.	From a continued rain of four hours.
4	W	29.74	49	S.	Poſ.	Nearly all day, but ſtrongeſt after ſunſet.
5	W	29.95	47	—	Poſ.	A. M.—and P. M. A cloudy atmoſphere.
6	S	29.75	53	—	Poſ.	The electricity of the atmoſphere this day has been ſo weak, that I have been obliged to content myſelf with obtaining the kind by a pair of flaxen threads, without balls to them. The weather warm and ſhowery.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November.
		Inch.	°			
7	S	29.68	57	S.	Poſ.	The operations in the rod, theſe two days, have been of the periodical kind. See 17th of October.
8	NE	29.90	42	S.	Poſ.	
9	NE	30. 3	44	—	Poſ.	Pith balls not open this day. The kind was obtained by flaxen threads without balls to them. A moiſt air.
10	NE	30.15	46	—	Poſ.	Sharp dark weather, theſe nine days, with a dry eaſterly wind; and a weak electricity.
11	E	30.	48	—	Poſ.	
12	NE	30.10	47	—	Poſ.	
13	NE	30.15	44	—	Poſ.	
14	NE	30.25	45	—	Poſ.	
15	NE	30.29	42	—	Poſ.	
16	NE	30.16	38	—	Poſ.	
17	E	30.	41	—	Poſ.	
18	N	29.77	33	—	Poſ.	
19	S	29.24	47	S.	Neg	The ſevere eaſterly wind is now gone, and a more intenſe atmoſpheric electricity is returned. Nine o'clock A. M. a large black cloud paſſed over the rod, and a moderate ſhower of rain fell, by which the rod was rather ſtrongly electrified negatively. This ſhower laſted one hour; and near the middle of it, the electricity changed to a ſtrong poſitive; after this, the electricity ended as it had begun, negative.
20	S	29.25	42	S.	Neg	By the night bottle. Half an hour after two o'clock P. M. fell ſome rain, and the rod became electrified negatively. At Calſtock, in Cornwall, in the evening of this day, much lightning and thunder.
21	W	29.16	47	S.	Neg	Half an hour after mid-day, fell a moderate ſhower of rain, attended with a great darkneſs. The rod now became rather ſtrongly electrified negatively; and the bell rang weakly. There were after this ſeveral ſhowers, which only gave a weak poſitive electricity; except one, which fell at ten o'clock at night; this indeed was ſtrongly poſitive. At eleven o'clock this night, both at London and Portſmouth, there was much lightning and thunder. And alſo, at the ſame time, at Saliſbury, where it appeared to roll along the ground like a body of liquid fire.
22	SW	29.40	49	—	Neg	A. M. The weather ſhowery.
23	NW	29.68	49	—	Poſ.	P. M. A foggy moiſt air.
24	SW	29.84	37	—	Poſ.	A. M. and P. M.
25	S	29.78	50	—	Neg	P. M. Weather ſhowery.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November and December.
		Inch.	°			
26	NW	29.58	51	—	Poſ.	Atmoſpheric electricity, theſe four days, has been governed by its periodical laws. The weather very mild.
27	N	30.20	36	—	Poſ.	
28	N	30.35	39	S.	Poſ.	
29	SE	30.12	35	S.	Poſ.	
30	N	29.74	32	S.	Poſ.	From a fall of ſnow.
1	SE	29.62	32	—	Poſ.	There has been very moderate weather theſe 12 days. The pith balls have been variable, between null, and nearly one inch open.
2	W	29.42	44	—	Poſ.	
3	S	29.83	45	—	Poſ.	
4	W	29.95	42	—	Poſ.	
5	NW	29.95	32	—	Poſ.	
6	N	30.30	38	—	Poſ.	
7	W	30.30	38	—	Poſ.	
8	N	30.15	49	—	Poſ.	
9	N	30.15	48	—	Poſ.	
10	W	30.18	48	—	Poſ.	
11	SW	29.95	52	—	Poſ.	
12	SW	30. 7	37	—	Poſ.	
13	SW	29.88	48	S.	Neg	There has been a conſtant drizzling rain, with a ſtrong gale of wind, from early in the morning to ſeven o'clock P. M.; the wind then became a ſtorm. The rod had been null to this time, but now gave ſigns of a negative charge, which continued increaſing until near nine o'clock; at this time the ſtorm ſeemed to be at its height, when the wind ſuddenly ſhifted from SW to N: every appearance is now awful; the pith balls diverge to their utmoſt limits, and are very much agitated; and the bell rang about half a minute. Half an hour after nine o'clock, the ſtorm ceaſed; and the charge in the rod became very weak. During the ſpace of two hours, the electricity changed ſix times.
14	W	29.91	39	—	Poſ.	A. M.
15	W	29.40	48	S.	Neg	From five to eight o'clock A. M. there was a ſtorm of wind and rain. The electricity changed once only.
16	S	29.71	39	—	Neg	P. M. A ſhowery day.
17	SW	29.41	41	—	Poſ.	A. M.
18	N	28.98	37	S.	Neg	A. M.—and P. M. Strong gales of wind, with rain.
19	S	29.54	33	S.	Poſ.	Between eleven and twelve o'clock A. M. fell a ſhower of rain, mixed with ſnow, by which the rod became rather ſtrongly electrified, poſitively; which continued, with ſome variation of intenſity (without change of kind) near three hours. The grateſt divergency of the pith balls was four inches, when fine ſparks were received from the braſs ball N.

Days.	Wind.	Barom	Ther.	Spark	Kind.	December and January, 1791.
		Inch.	°			
20	N	29.93	32	—	Poſ.	Nearly all day. Divergency three-quarters of an inch. Weather ſerene.
21	SW	29.90	46	—	Poſ.	The air is extremely moiſt; and ſome ſmall rain fell ſeveral times this day, which was almoſt void of the electric fluid; for I could not obtain it in quantity ſufficient to aſcertain the kind, until I added a LIGHTED PITCH TORCH to my hand exploring-rod. See fig. 2.
22	W	30. 5	37	—	Poſ.	The pith balls half an inch open nearly all day.
23	W	29.80	44	—	Poſ.	Five o'clock this morning, a moſt tremendous ſtorm of wind, rain, lightning, and thunder, viſited London and other parts. I, being not well, and in bed, did not get up to make obſervations. I thought I heard the bell ring: however, the rod was but weakly electrified the reſt of the day. The high wind continued, without rain, all day.
24	SW	30.20	39	—	Poſ.	Moderate weather theſe ſix days, and nearly a conſtant charge of electricity in the rod.
25	N	30.	45	—	Poſ.	
26	SW	30.22	29	S.	Poſ.	
27	S	30. 3	31	—	Poſ.	
28	N	30.	32	—	Poſ.	
29	S	30.20	25	—	Poſ.	
30	S	29.96	37	S.	Neg	P.M. A fair morning, and a wet evening.
31	N	30. 5	38	—	Poſ.	The rod has been electrified nearly all day, by a fog.
1	S	30. 2	40	—	Poſ.	A.M. In the evening negative, from a fall of rain. This evening much lightning and thunder at Canterbury.
2	SW	29.72	31	S.	Poſ.	A.M. A foggy morning. Half an hour after eight o'clock P. M. happened a ſudden gale of wind and rain, by which the rod became rather ſtrongly electrified, negatively.
3	SW	29.40	29	S.	Poſ.	The morning of this day was froſty, and the evening wet. The electricity of the former was poſitive, and the latter negative.
4	SW	29.40	38	—	Neg	P.M. Balls three-quarters of an inch open. Strong gales of wind, with rain. Nine o'clock P. M. ſevere lightning and thunder at Falmouth.
5	SW	29.29	35	—	Poſ.	Very fine weather theſe four days. Divergency of the pith balls have been between null and near one inch open.
6	SW	29.46	37	—	Poſ.	
7	W	29.18	51	—	Poſ.	
8	W	29.26	43	—	Poſ.	
9	W	28.96	42	S.	Neg	Eight o'clock A. M. I ſaw a large black cloud in the NNW: ſoon after, a ſtrong

Days.	Wind.	Barom	Ther.	Sparks	Kind.	January and February.
		Inch.	°			
						wind ſuddenly ſprang up, and a little rain fell; during which, the rod was rather ſtrongly electrified negatively, with ſmall ſparks. This charge of the rod only laſted eighteen minutes.
10	S	29.75	42	—	Poſ.	Fine weather, and almoſt a conſtant electricity theſe two days.
11	W	29.75	48	—	Poſ.	
12	S	29.95	42	—	Poſ.	P. M. A very high wind, and a weak electricity. In the evening of this day, much lightning and thunder at Plymouth.
13	W	29.48	43	—	Neg	P. M. from a ſhower of rain.
14	W	29.80	42	—	Poſ.	Very moderate weather, and a weak electricity, theſe four days.
15	SW	30.	32	—	Poſ.	
16	SW	29.82	50	—	Poſ.	
17	SW	29.50	49	—	Poſ.	
18	S	29.50	42	—	Neg	From rain, with a ſtrong wind.
19	S	28.87	43	—	Neg	
20	SW	28.48	43	—	Poſ.	The weather for theſe twelve days having been moderate, the electricity of the atmoſphere has only been of ſuch intenſity as is common to ſerene weather.
21	W	29.22	37	—	Poſ.	
22	S	29.85	35	—	Poſ.	
23	W	29.76	48	—	Poſ.	
24	S	30.50	32	—	Poſ.	
25	SW	30.27	45	—	Poſ.	
26	SW	30.15	45	—	Poſ.	
27	SW	29.84	45	—	Poſ.	
28	N	30.	33	—	Poſ.	
29	SW	30.	38	—	Poſ.	
30	NW	29.85	44	—	Poſ.	
31	NW	29.85	51	—	Poſ.	
1	W	29.85	47	S.	Poſ.	P. M. from a ſhower of rain, of large drops; the rod became electrified rather ſtrongly poſitive, and emitted fine bright ſparks at the braſs ball N,
2	N	30.	38	—	Poſ.	The weather theſe nine days have been foggy and clear by turns; and the electrification of the atmoſphere conſtant.
3	N	30.20	32	—	Poſ.	
4	N.	30.40	32	—	Poſ.	
5	N	30.45	36	—	Poſ.	
6	SW	30.40	36	—	Poſ.	
7	NW	30.32	42	—	Poſ.	
8	W	30.36	43	—	Poſ.	
9	SW	30.32	43	—	Poſ.	
10	SW	30. 8	46	—	Poſ.	
11	SW	29.80	49	—	Poſ.	There has been, theſe three days, a ſtrong wind, with mizzling rain; and the electricity ſo weak, that I was obliged to connect, with the hand-rod, A LIGHTED TORCH, to aſcertain the kind.
12	W	30.11	36	—	Poſ.	
13	SW	29.95	46	—	Poſ.	

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	February and March.
		Inch.	°			
14	SW	29.88	53	—	Poſ.	Fine mild weather, with a conſtant electricity, theſe five days.
15	SW	29.80	47	—	Poſ.	
16	SW	29.85	43	—	Poſ.	
17	SW	30.10	40	—	Poſ.	
18	SW	29.35	30	—	Poſ.	
19	NE	29.40	37	S.	Poſ.	Five o'clock, a dark cloudy morning, with ſome ſmall rain; by which the rod became rather ſtrongly electrified, poſitively. During the paſſage of ſome low clouds, the electric charge in the rod changed five times; all of which changes, I have reaſon to think, were only influentially effected.
20	NE	29.80	40	S.	Poſ.	A.M. Rainy dark weather. In the afternoon the charge in the rod became negative, and remained ſo full three hours, without change of kind.
21	S	29.56	42	—	Poſ.	Dark rainy weather, and a very weak electricity.
22	SW	29.73	32	—	Poſ.	
23	SW	29.55	47	—	Poſ.	
24	W	29.90	33	—	Poſ.	
25	E	30.	37	S.	Poſ.	There has happened this day a continued rain, mixed with ſnow. The rod has been ſeveral times ſtrongly charged; and the electricity gradually changed four times.
26	N	29.72	33	S.	Poſ.	The weather and the electrification of the rod have been nearly the ſame as in the preceding day.
27	N	30.	38	S.	Poſ.	The weather and the operations of the rod have been nearly the ſame as in the two preceding days.
28	N	30. 8	36	—	Poſ.	The weather has been foggy theſe three days.
1	N	30.12	35	—	Poſ.	
2	S	30.25	32	—	Poſ.	
3	SW	30.50	32	—	Poſ.	Serene fair weather theſe ſeventeen days; and the nights were generally froſty. The electricity of the atmoſphere has been conſtant; but too weak to afford viſible ſparks.
4	SW	30.40	45	—	Poſ.	
5	SW	30.44	47	—	Poſ.	
6	SW	30.20	40	—	Poſ.	
7	NW	30.25	41	—	Poſ.	
8	N	30.55	37	—	Poſ.	
9	SW	30.65	34	—	Poſ.	
10	W	30.55	35	—	Poſ.	
11	SW	30.46	39	—	Poſ.	
12	W	30.28	40	—	Poſ.	
13	SW	30.20	44	—	Poſ.	
14	SW	30.18	47	—	Poſ.	
15	SW	30.35	50	—	Poſ.	
16	SW	30.40	51	—	Poſ.	
17	SW	30.40	40	—	Poſ.	
18	SW	30.28	50	—	Poſ.	
19	SW	30.15	39	—	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	March.
		Inch.	°			
20	W	29.68	46	—	Neg	This morning fell a warm drizzling rain; which ſeems to have acted like a charm on the late conſtant electrification of the atmoſphere: for I find it ſo weakly electrified ſince the rain fell, that I have been obliged to connect, with the rod, A LIGHTED TORCH, to aſcertain the kind.
21	NW	29.15	44	S.	Poſ.	Four o'clock this morning, a ſevere ſtorm of wind and rain, driving full againſt my bed-room window, induced me to riſe from my bed to ſee the ſtate of the rod; which I found highly electrified, poſitively. This wind did not abate its force till ſun-ſet. Four o'clock P.M. ſome rain fell, mixed with ſnow, which laſted near one hour. During this time, the rod was moſt powerfully electrified, poſitively: I counted ſeventeen ſpontaneous exploſions between the braſs ball and bell, notwithſtanding the bell was ringing all the time. Half an hour after five o'clock, came a ſecond ſhower of rain, hail, and ſnow, which laſted half an hour, attended with uncommon darkneſs: about half of this time, the electric charge in the rod was as ſtrong as it could poſſibly be; for the fluid almoſt ſtreamed between the braſs ball and bell: I counted near two hundred very brilliant exploſions between the ball and bell. The bell rang all the time. This latter very high charge, was firſt negative; attended with four changes of electricity, but all gradual.
22	N	29.85	44	—	Poſ.	The diſpoſition of the atmoſphere has been mild and regular theſe four days; and the ſtate of atmoſpheric electricity conſtant and periodical.
23	W	30. 8	54	—	Poſ.	
24	N	30.50	44	—	Poſ.	
25	S	30.38	43	—	Poſ.	
26	S	29.85	46	S.	Neg	Half an hour after nine o'clock, A. M. fell ſome rain, by which the rod became electrified, negatively. Soon afterwards the wind became N, and attended with ſhowers of rain the reſt of the day: all of them moderately electrified, negatively.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	March and April.
		Inch.	°			
27	N	30.	40	—	Poſ.	The weather has been fair during theſe ten days, and the atmoſpheric electricity has been conſtant; yet it has been too weak to afford viſible ſparks.
28	NW	30.10	45	—	Poſ.	
29	SW	30. 6	50	—	Poſ.	
30	E	30.	44	—	Poſ.	
31	SE	30. 8	44	—	Poſ.	
1	SW	30.	50	—	Poſ.	
2	E	29.81	51	—	Poſ.	
3	E	29.78	50	—	Poſ.	
4	NE	29.90	46	—	Poſ.	
5	NE	29.72	46	—	Poſ.	
6	N	29.45	43	S.	Neg	Six o'clock, A.M. I found the night bottle charged ſufficiently to explode with a viſible ſpark; the kind, negative. During the night, the weather had changed from dry to a mild rain. The rod has been electrified negatively nearly all this day.
7	W	29.78	47	—	Poſ.	Mild ſerene weather. The divergency of the pith balls has been varying between null and nearly one inch open.
8	NW	29.92	53	—	Poſ.	
9	NW	29.90	51	—	Poſ.	
10	W	30.	50	—	Poſ.	
11	SE	30.	50	S.	Neg	Weather ſtill mild, and a conſtant electricity this day.
12	N	29.95	54	—	Poſ.	From a fog.
13	NE	30.	51	—	Poſ.	Mild ſerene weather theſe nine days; ſome of them foggy: but whether clear or foggy, the vapour in the air has been conſtantly electrified, poſitively.
14	W	30.	59	—	Poſ.	
15	SW	30. 6	55	—	Poſ.	
16	SE	30.10	55	—	Poſ.	
17	SE	30.	61	—	Poſ.	
18	SW	29.80	57	—	Poſ.	
19	SW	29.75	59	—	Poſ.	
20	S	29.57	59	—	Poſ.	
21	SW	29.48	56	—	Poſ.	
22	SW	29.25	55	S.	Neg	A wet morning. Twelve o'clock, the rain fell more plentifully, and the rod was rather ſtrongly charged, negatively.
23	SW	29.24	54	S.	Neg	Half an hour after twelve o'clock, P.M. an extenſive black cloud, without any breaks in it, approached the rod, by which it became ſtrongly electrified, negatively; and, in the ſpace of twelve minutes, a moſt awful darkneſs filled the atmoſphere, and ſome rain fell, mixed with hail. The electric charge in the rod now became poſitive; and, for the ſpace of ten minutes, it was as ſtrongly electrified as it poſſibly could be; for I now counted 172 ſpontaneous exploſions between the braſs ball and bell; the bell ringing briſkly all the time. Theſe lucid ſparks ſucceeded each other almoſt too quick to be noted. When the exploſive ſparks ceaſed, the electricity

Days.	Wind.	Barom	Ther.	Sparks	Kind.	April and May.
		Inch.	°			of the rod changed, and ended as it had begun, negative. A little after five o'clock fell a heavy ſhower of rain, and a ſecond ſtrong charge in the rod ſucceeded, attended with three gradual changes of kind.
24	SW	29.31	54	S.	Neg	A little after two o'clock, P. M. fell a ſhower of rain, by which the rod became moderately electrified, negatively. The bell rang weakly. This charge in the rod continued four hours, without change of kind.
25	W	29.84	51	S.	Poſ.	A. M. Three o'clock, P. M. fell a ſhower of rain, which was rather ſtrongly electrified, negatively, attended with three changes of kind.
26	E	30.	53	—	Poſ.	Serene foggy weather theſe three days.
27	NE	29.84	53	—	Poſ.	
28	N	29.81	52	—	Poſ.	
29	N	29.86	51	S.	Neg	A. M. from a ſhower of rain.
30	N	29.90	48	S.	Neg	During the greateſt part of the day. The weather ſhowery.
1	N	29.80	48	S.	Poſ.	A. M. Afternoon negative. The weather ſtill ſhowery.
2	N	29.85	48	S.	Neg	A. M. A mild ſhowery morning.
3	N	30.	45	—	Poſ.	A. M. but very weak. Fair weather to-day.
4	N	30.	45	—	Poſ.	The atmoſpherical electricity has been ſo very weak this day, that I was obliged to connect, with the hand-rod, a LIGHTED TORCH, to aſcertain the kind of electricity.
5	N	29.96	47	—	Poſ.	Fair ſerene weather theſe four days; and the atmoſpheric electricity conſtant.
6	N	30.	46	—	Poſ.	
7	N	30.28	45	—	Poſ.	
8	N	30.32	48	—	Poſ.	

A Monthly Account of Sparks, and of Poſitive and Negative Electricity, as indicated by the Pith-ball Electrometer, connected with the rod; excepting a few times, in very moiſt weather, in which it was obtained by the hand exploring-rod, with a lighted TORCH *to it.* See fig. 2.

	Times	Times	Sparks drawn Days.
23 days May, 1790 8 days May, 1791	Poſ. 40	Neg. 27	13
June	Poſ. 45	Neg. 22	5
July	Poſ. 36	Neg. 23	8
Auguſt	Poſ. 33	Neg. 6	3
September	Poſ. 39	Neg. 11	19
October	Poſ. 37	Neg. 7	22
November	Poſ. 30	Neg. 8	11
December	Poſ. 35	Neg. 11	6
January	Poſ. 28	Neg. 8	3
February	Poſ. 36	Neg. 12	6
March	Poſ. 34	Neg. 8	2
April	Poſ. 30	Neg. 14	8
	423	157	106

It appears, by comparing the monthly account of this year with that of the preceding, that there has been a conſiderable diſproportion in the electrical poſitive ſtate of the atmoſphere; but which, when duly weighed, will not appear ſo great as it now does. For when it is conſidered, that in the preceding year there were 73 days in which weak ſigns only of the electric fluid were obſerved; that ſeven days were deſtitute of electric ſigns; and that that kind of weather in which very weak ſigns of atmoſpherical electricity could be obtained, is now found, by a more ſenſible electrometer than was at that time uſed, to be always

ways poſitively electrified, it will, I preſume, diminiſh the apparent diſproportion. And as for the remaining difference, I alſo attribute a good deal of it to the accuracy of my preſent mode of obtaining atmoſpherical electricity, with a more complete apparatus; by which I have been able to collect the electric fluid, in ſufficient quantity to aſcertain the kind which predominates in the atmoſphere, even in its weakeſt ſtate. I have, therefore, found it an eaſy matter to fix the kind of electricity that the aqueous vapours in the air were charged with in each day throughout the year.

From repeated obſervations, and long experience, I am perfectly ſatisfied that the aqueous vapours, ſuſpended in the air, are conſtantly electrified; requiring only the aid of a proper collector, to render the effects of their electricity at all times ſenſible. And for this reaſon, there may be juſtly ſaid to be an electrical atmoſphere within our aerial atmoſphere.

During a courſe of moderate weather, the electricity of the atmoſphere is invariably poſitive; and exhibits a flux and reflux, which generally cauſes it to increaſe and decreaſe twice in every twenty-four hours. The moments of its greateſt force are about two or three hours after the riſing, and ſome time before and after the ſetting, of the ſun; thoſe when it is weakeſt, are from mid-day to about four o'clock. The periodical electricity of the atmoſphere ſeems to be manifeſtly influenced by *heat* and *cold*. Hence it plainly appears, why we always find warm ſmall rain to be but weakly electrified; when cold rain, which falls in large drops, is the moſt intenſely electrified of any.

The abovementioned eighth day of May, completes my ſecond year's Journal; which, agreeable to my promiſe, I have now the honour of preſenting to the Royal Society, with a deſcription of the improved atmoſpheric apparatus, which has been uſed for the foregoing obſervations.

I muſt now cloſe that regular account which, for the laſt two years, has daily occupied my attention. Should any very remarkable appearances, however, in future take place, during a long courſe of froſty weather, which is the only ſtate of the atmoſphere that I have not yet experienced *, as my apparatus will continue in order, I ſhall carefully note them, and preſent them to the Royal Society: hoping that ſome more able philoſopher may be induced to take his ſhare of labour in this intereſting and promiſing field, in order to inveſtigate, as far as poſſible, the nature of ſo active, univerſal, and, in all probability, important an agent, as the atmoſpherical electricity ſeems to be; and to purſue the ſubject, with that diligence, and unprejudiced accuracy, which has been my principal object in the courſe of my obſervations.

---

* As I do not remember that there have been twenty-four hours of hard froſt during the laſt two winters.

The ſix following Pages (which I beg leave to ſubjoin) have not been preſented to the Royal Society.

Though the nature and confined limits of the plan of the preceding Journals, did not admit of much variety of obſervation, or a formal enumeration of every particular fact; yet few things, I hope, of uſe and importance have been omitted. But, I wiſh, in a more particular manner, to invite the philoſophic reader to the inveſtigation of the three following effects, which are in themſelves, I think, the moſt peculiar; and have already been ſhortly noticed, when they happened to take place in the rod, in ſeveral parts of the Journals; and which I beg leave to do, for the ſake of conciſeneſs, by way of interrogation.

Firſt, When the high pointed rod is intenſely electrified, and the pith-balls annexed to it, diverging five or ſix inches, why ſhould they exhibit a waving pendulous motion, without any diminution of their divergency, but vibrate as if the threads and balls were one ſolid and inflexible ſubſtance?

Secondly, By what means, and in what manner are the electricities of the earth and atmoſphere acted upon, ſo as to cauſe the pith balls to exhibit very quick jerks, by a ſudden loſs of intenſity, from five to three, two, or even one inch aperture, while yet the balls as quickly recover their former intenſity, and ſometimes recover it but ſlowly? Theſe ſudden jerks are never attended with a change of electricity, but the facts themſelves happen in both kinds.

Thirdly, In what manner do the powers of nature effect a total diſcharge of the highly electrified rod, in an inſtant of time, and the next inſtant render it highly electrified

as

as at the firſt, and either with or without a change of electricity? Theſe ſtriking effects and appearances, I own, are attended with conſiderable difficulties; of which I cannot, at preſent, give a ſolution ſatisfactory to myſelf, nor can I even imitate them by artificial electricity. The following circumſtances, however, are clear, that theſe effects never happen with a weak electrification of the rod, nor always with a ſtrong one; but they are always more or leſs diſplayed, when a flaſh of lightning happens in the neighbourhood of the rod, or is ſtrongly preſumed to have happened at no great diſtance from it. As theſe effects appear to be immediately connected with an exploſion of lightning, they may poſſibly ſerve as a clue to the more complete inveſtigation of that phenomenon; and are, therefore, worthy of the regard, and the moſt minute examination of the philoſopher.

The following Obſervations are chiefly ſelected from the Works of Mr. ACHARD *and* Mr. CAVALLO.

Mr. ACHARD obſerves, on the imperfection of Meteorology, that little progreſs will be made in it, ſo long as barometrical, thermometrical, and hygrometrical obſervations are not accompanied with the regular obſervations of the electricity of the atmoſphere, of the electricity of rain, hail, ſnows, miſts, and aqueous meteors in general. As it is now clearly aſcertained, that electricity is a cauſe of various meteorological phenomena, it is rather ſurpriſing that philoſophers have not perceived the abſolute neceſſity of joining an inſtrument, by which obſervations may be made on the electricity of the atmoſphere, to thoſe which indicate its weight, heat, and humidity.

Without conſidering, in this place, the different proofs of the influence of electricity on meteors, it will be ſufficient to remark, that we cannot attain to an adequate knowledge of any phenomenon occaſioned by the concurrence of various cauſes, without being acquainted with them all; for, if any one is neglected, it will be abſolutely impoſſible thoroughly to explain the phenomenon. If electricity is not the ſole cauſe of ſeveral meteorological appearances, it is undoubtedly concerned more or leſs in their formation and elevation; ſo that by neglecting to obſerve it, as well as the barometer, &c. we looſe the fruits of other, even very exact, meteorological obſervations.

The influence of electricity on vegetation, is proved by a ſet of obſervations made by different philoſophers; but it evidently appears, that the botanic meteorological obſervations alone will never be ſo uſeful as might be expected, till we unite thoſe made by an inſtrument, which will indicate the electric ſtate of the atmoſphere to thoſe made with other inſtruments. It is owing to this cauſe, perhaps, that it is impoſſible to draw any concluſion from the botanical meteorological obſervations of Meſſrs. Gautier and Duhamel, which were continued from 1751 to 1769.

It is remarkable, that in thoſe days in which he obſerved no electricity in the air, there was no dew at night; while, on the other nights, it fell in greater or leſs quantities. Mr. Achard does not think thoſe obſervations ſufficient to determine that dew is occaſioned by electricity; but it may, he thinks, be fairly inferred, that the elevation and fall of the dew is obſtructed, or promoted by the electricity of the air.

As electricity is often, if not always, the cauſe of dew, no one will doubt the neceſſity of attending to it in the botanical meteorology; as every one is acquainted with the influence of dew on the growth of vegetables.

Having endeavoured to prove the neceſſity of combining obſervations on the electricity of the atmoſphere, with other meteorological obſervations, Mr. ACHARD proceeds to deſcribe the properties requiſite in a good atmoſpherical electrometer, the want of which accounts for the neglect and ſupineneſs of philoſophers on this ſubject.

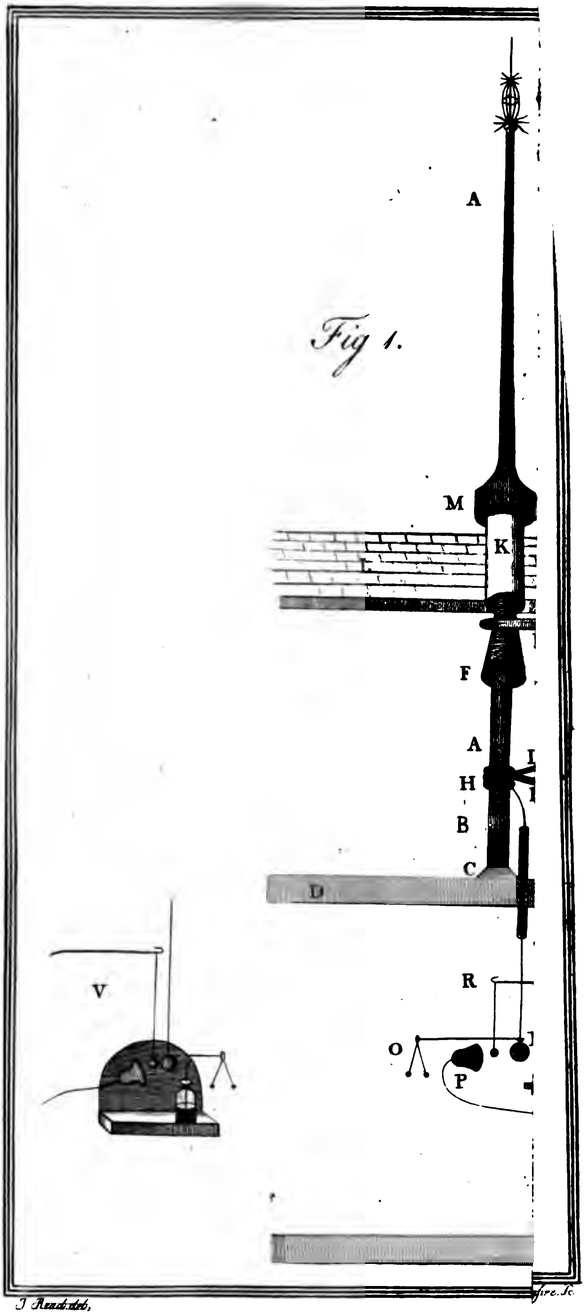
Mr. CAVALLO, on this ſubject, ſays it appears, from the obſervations which have been made on the electricity of the atmoſphere, that nature makes great uſe of this fluid in promoting vegetation.

1ſt. In the ſpring, when plants begin to grow, then temporary electrical clouds begin to appear, and pour forth electric rain. The electricity of the clouds and of the rain continues to increaſe till that part of the autumn in which the laſt fruits are gathered.

2dly, It is this fluid which ſupplies common fire with that moiſture; by the help of which, it actuates and animates vegetation; it is the agent that collects the vapours, forms the clouds, and is then employed to condenſe them into rain.

3dly, From the ſame principle may be explained the proverb, that *no watering gives the country ſo ſmiling a look as rain.* The clouds which bring the rain, by extending their electric atmoſphere to the plants, diſpoſe the pores of the latter to receive with greater facility the water which is impregnated with this penetrating and dilating fluid. Beſides, it is natural to ſuppoſe, that the poſitive electricity which continually prevails in ſerene weather, will contribute to promote vegetation, ſince this has been found to be the effect even of artificial electricity.

FINIS.



J Read del,

fire. Sc.